R E P O R T R E S U M E S

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VOCATIONAL TALENTS EXERCISES, PART C.

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THIS WORKBOOK WAS DEVELOPED IN A CURRICULUM PROJECT DESCRIBED IN VT 004 454 TO HELP YOUNG PEOPLE LEARN BASIC PRINCIPLES AND CONCEPTS OF MECHANICS AND TECHNOLOGY. IT IS THE THIRD OF FOUR BOOKS WHICH PRESENT 30 EXERCISES DESIGNED FOR 30 CLASS PERIODS. THE EXERCISES, SIMILAR TO THOSE IN APTITUDE TESTS, COVER ABSTRACT REASONING, TECHNICAL COMPREHENSION, AND THREE-DIMENSIONAL VISUALIZATION. EXERCISE ITEMS ARE MULTIPLE CHOICE QUESTIONS, LINE DRAWINGS, AND NUMBER SERIES. ANSWERS ARE AVAILABLE IN VT 004 461. OTHER RELATED DOCUMENTS ARE VT 004 455 THROUGH VT 004 471. (EM)

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VOCATIONAL TALENT EXERCISES

PART C

The George Washington University
School of Education
Education Research Project
Washington, D.C.
1966

VT004460

INTRODUCTION

Several important talents have been found to be very necessary for success in training for good jobs with a future. Your ability in these skills may be measured and used as indicators of your chances of success at different times during your lifetime. Therefore, how well you do in life may depend on how well you master these exercises.

This booklet is the third in this series and continues the exercises of Parts A and B. Part D will contain exercises very similar to those in this booklet. Practice in doing these exercises should increase your ability to succeed in important training programs later on.

The answers to these exercises have been printed separately and supplied to the teachers only.

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Exercise 16

GETTING THE IDEA

(Abstract Reasoning--Part 5)

Before attempting to do these new problems you should review the past exercises on abstract reasoning. Refresh your memory regarding the principles of direction, size, and relative motion.

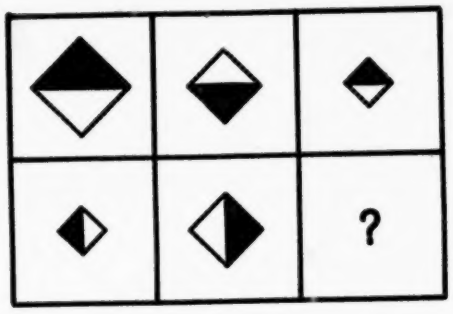
Always remember that each problem may use one or more principles.

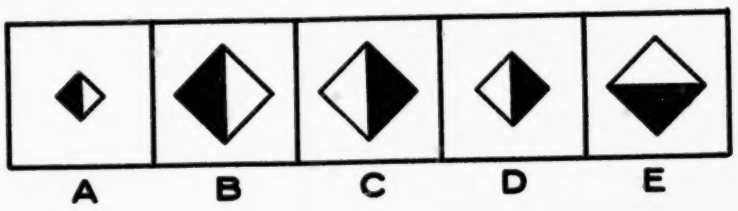
Several problems in this exercise contain a new principle. It is a simple principle and you will be able to find the answer without too much difficulty.

When your teacher tells you, turn the page and start the exercise. Circle the letter under the box which has the drawing you think is correct.

Drill 1

1





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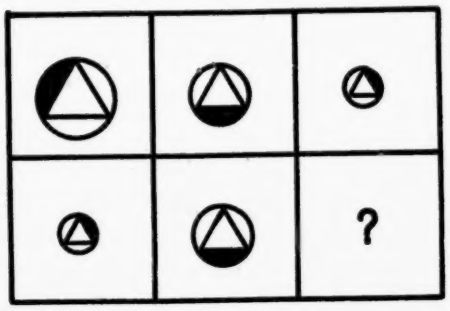

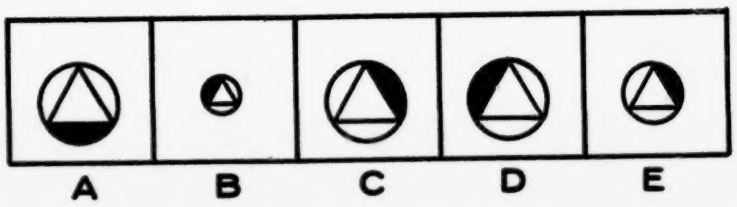

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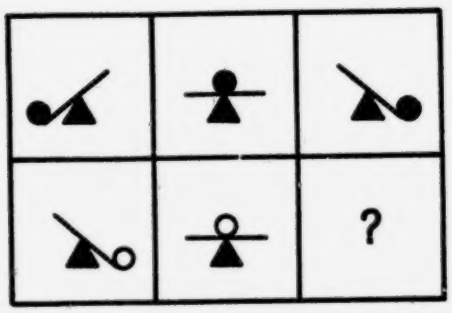

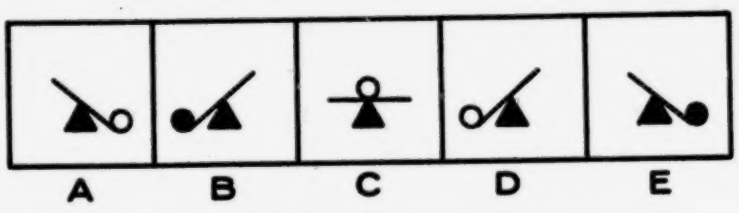

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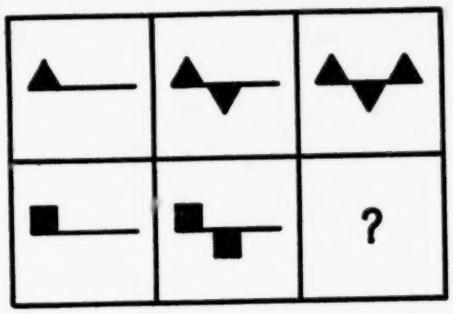

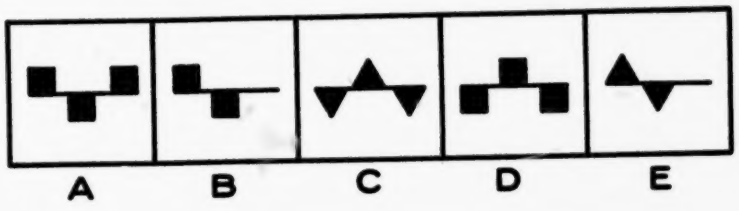

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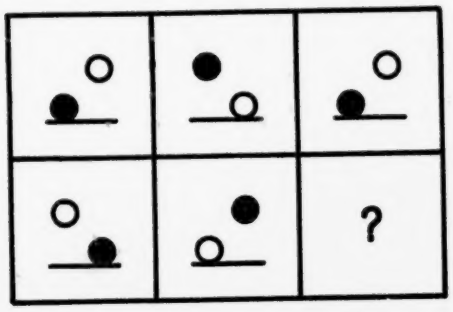

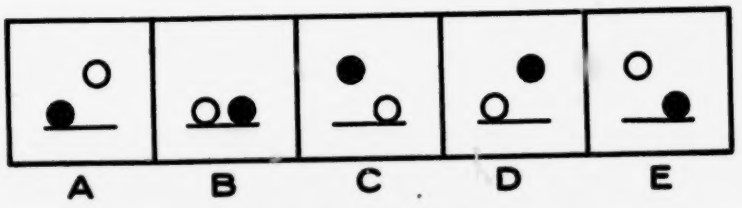

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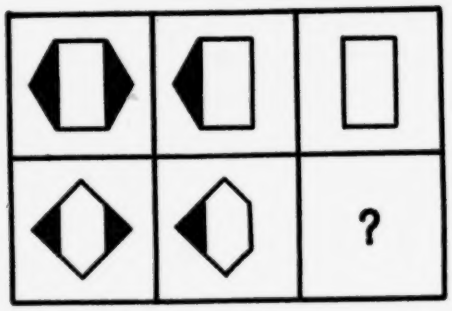

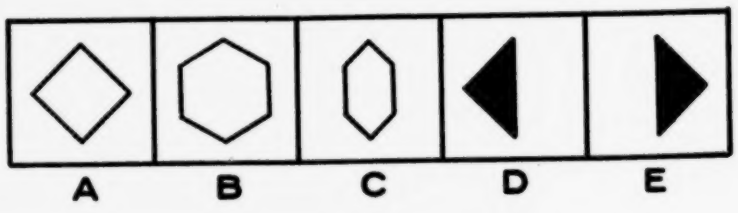

Drill 2

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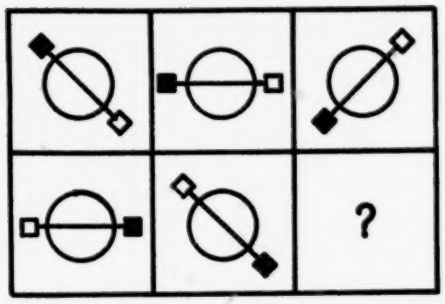

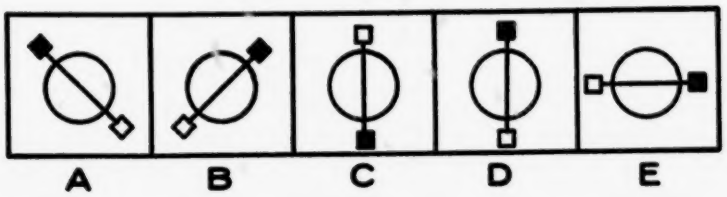

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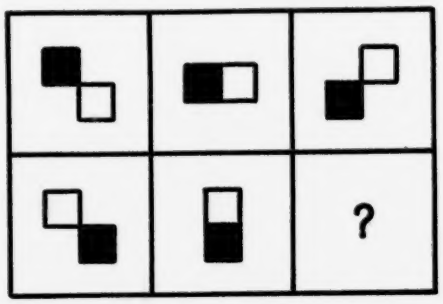

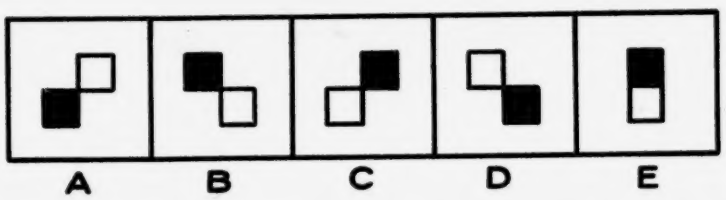

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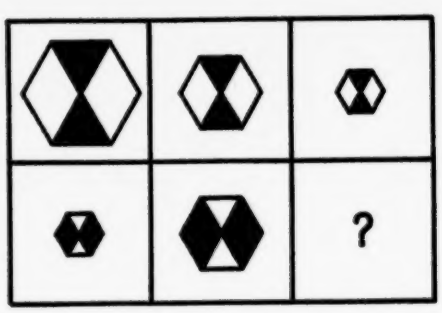

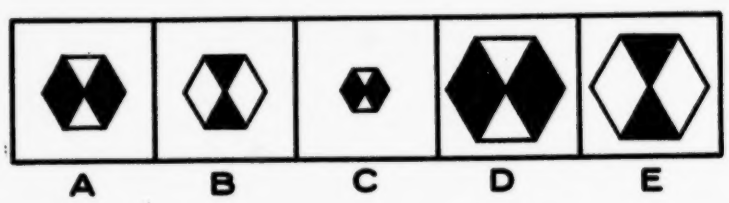

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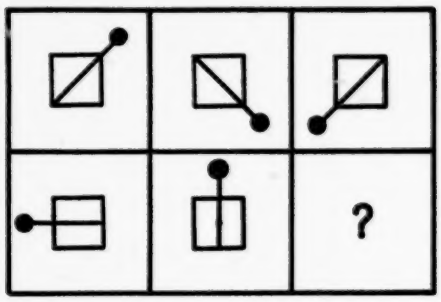

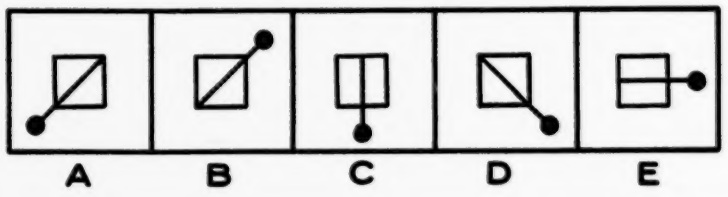

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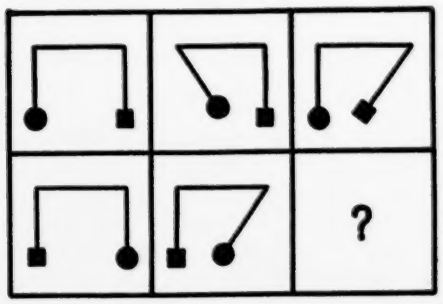

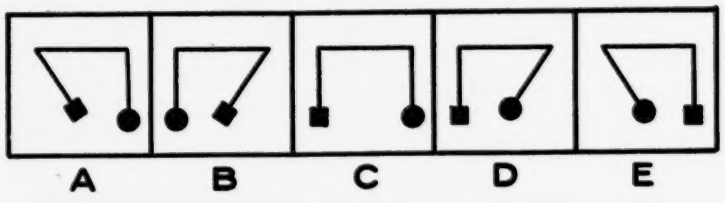

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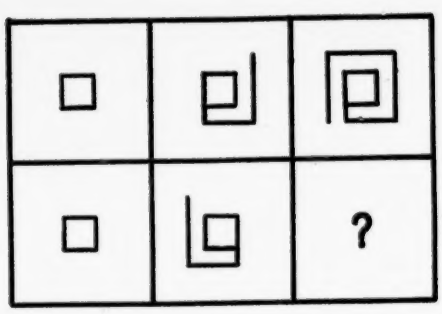

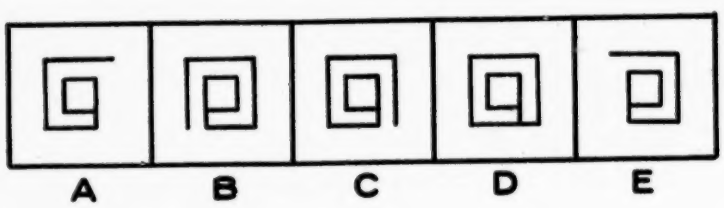

Drill 3

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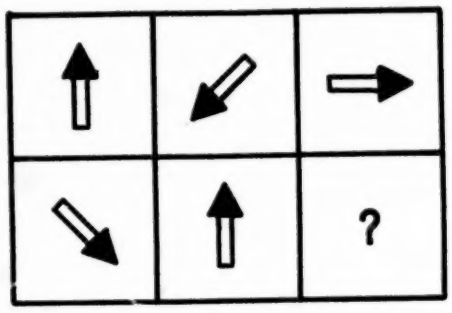

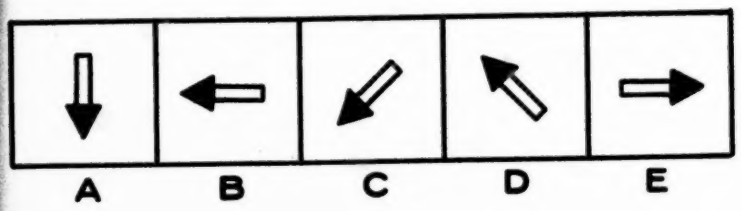

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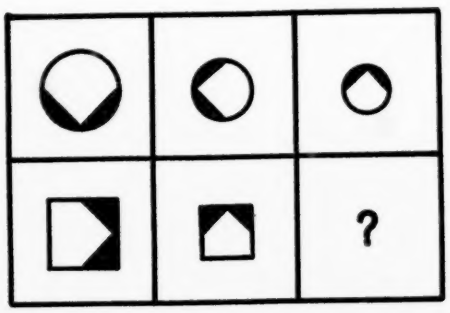

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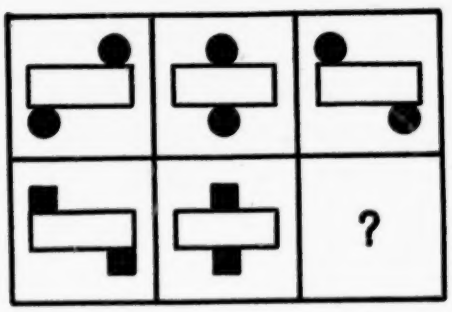

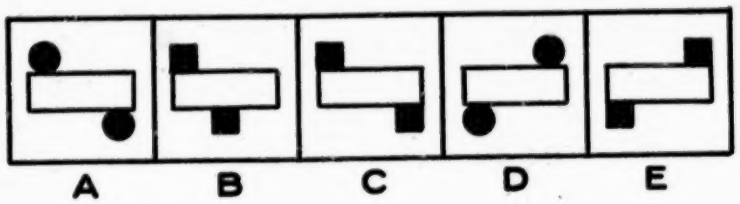

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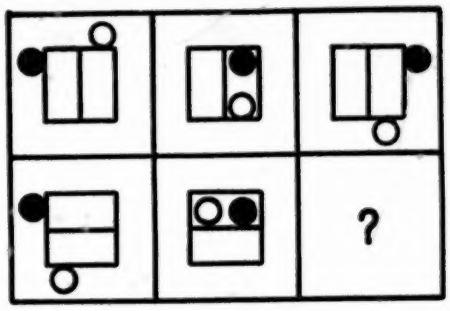

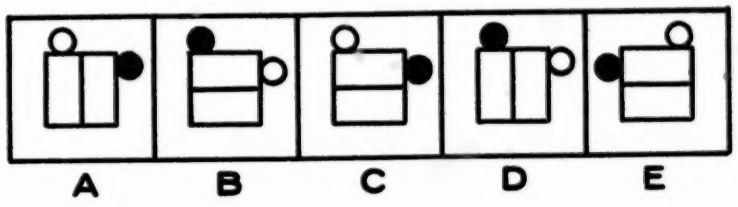

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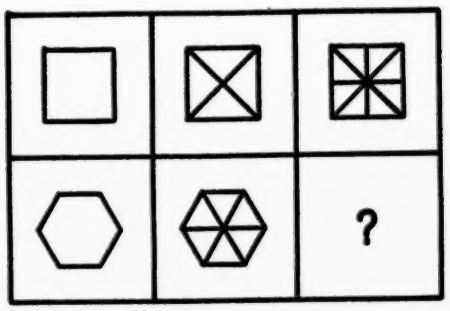

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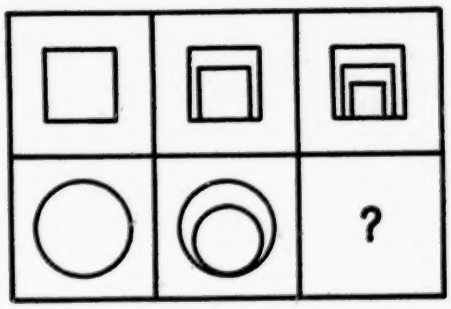
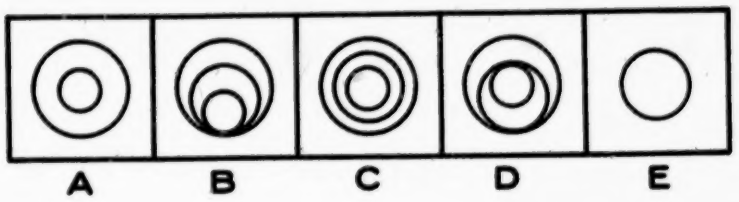
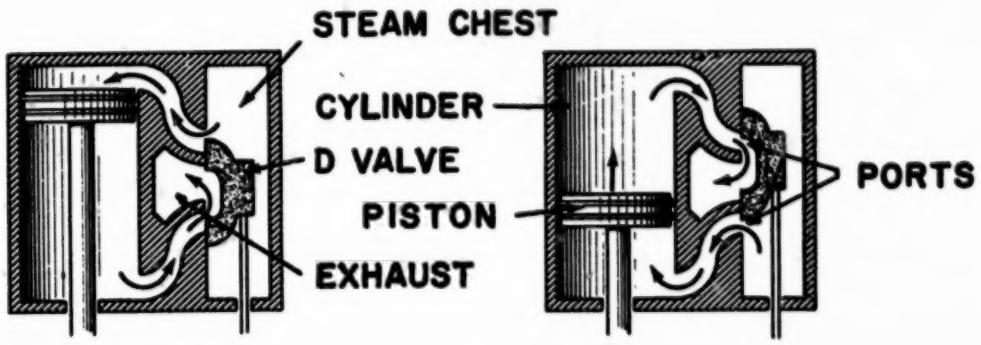




Exercise 17
Part 1

THE STEAM ENGINE



This is a diagram of the steam chest, cylinder, piston, and D valve of a railroad locomotive. Steam under high pressure goes from the boiler to the steam chest. From the steam chest it is fed alternately through the two small openings, called ports, into the cylinder. The upper port is open in the left-hand diagram.

The steam expands as it enters the cylinder. The expanding steam pushes the piston toward the other end of the cylinder. At the same time, the old steam goes out of the other side of the piston through the other port to the exhaust in the center.

When the piston nears the end of the cylinder, the port that let the steam in is closed by the D valve. When the D valve moves, the other port opens, letting steam in on the other side of the piston. The steam then forces the piston back to its former position. This is shown in the right-hand diagram.

When the piston nears the other end of the cylinder, the D valve again moves, closing the bottom port and opening the top one. The cycle then starts all over again.

Exercise 17
Part 1

QUESTIONS

These questions refer to the diagram of the steam engine. Put a circle around the letter in front of the correct answer.

1. When the steam leaves the steam pipe, it goes first to the

   A. cylinder.
   B. boiler.
   C. exhaust valve.
   D. steam chest.

2. When the steam leaves the steam chest, it enters

   A. the steam pipe.
   B. the cylinder.
   C. the boiler.
   D. the exhaust valve.

3. The movement of the piston forces the old steam

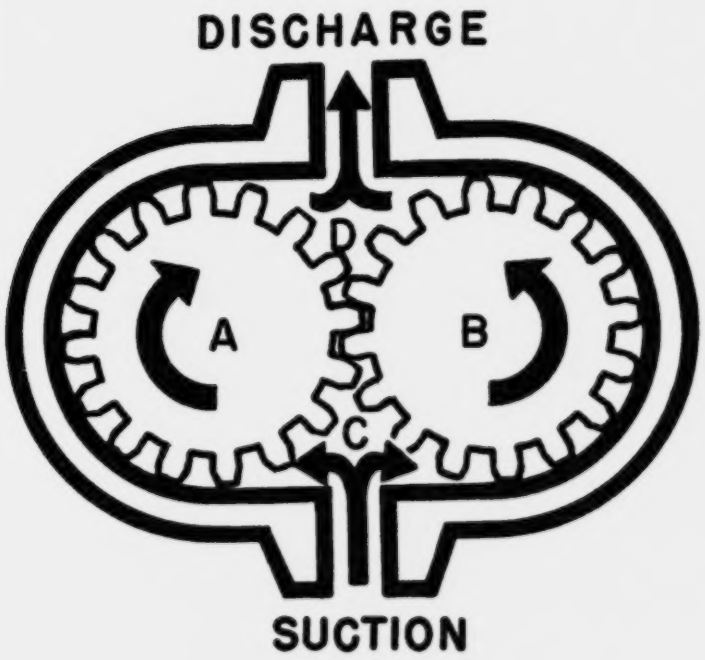
   A. through the exhaust.
   B. back to the steam chest.
   C. into a steam pipe.
   D. into a corner of the cylinder.

4. The D valve is located in the

   A. piston.
   B. cylinder.
   C. steam chest.
   D. boiler.

Exercise 17
Part 2

A ROTARY PUMP



This is a rotary pump. Gears A and B rotate in opposite directions. Gear A is driven by a power source and gear B turns freely. Liquid enters the pump at the bottom and is carried up to the discharge in the small spaces formed between the gear teeth and the wall of the pump chamber.

As the gears carry the liquid away from chamber C, a pair of teeth open up at the center of the pump. This reduces the pressure in chamber C. As a result, liquid comes up the suction pipe.

When each pocket of liquid caught between the teeth and the side of the pump reaches chamber D, it is prevented from returning to chamber C by the meshing of gears at the center of the pump chamber. The gear teeth are designed to form a continuous seal there. The liquid is then forced out of the pump through the discharge pipe.

Exercise 17
Part 2

Rotary pumps are widely used to pump lubricating oil in automobile engines. They do not take much power to operate.

QUESTIONS

These questions refer to the diagram of the rotary pump. Put a circle around the letter in front of the correct answer.

1. The liquid flows from
   A. C to D.
   B. D to C.

2. The liquid flows
   A. between the gears.
   B. around the outside of the gears.

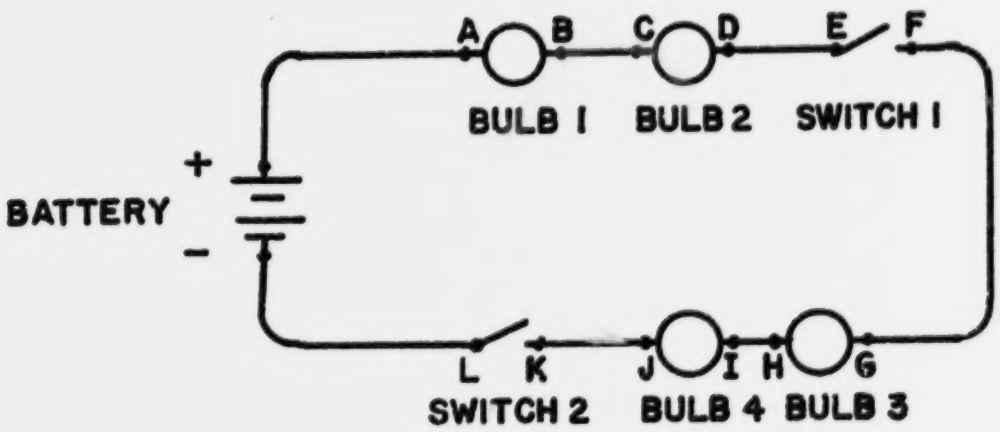
3. The pressure is greater in
   A. chamber C.
   B. chamber D.

4. Liquid flows into
   A. chamber C.
   B. chamber D.

5. The liquid is carried
   A. more by gear A.
   B. more by gear B.
   C. equally by each gear.

Exercise 17
Part 3

A SIMPLE SERIES CIRCUIT



This is a diagram of an electric circuit. When the two switches are closed, the electric current goes from one terminal of the battery and flows through the wires, bulbs, and switches (through points A, B, C, D, E, F, G, H, I, J, K, and L, in turn) back to the other terminal of the battery. Current will not flow if either of the switches is open. The switches are shown open in the diagram.

When both switches are closed, all four bulbs will light up. Removing a bulb will break the circuit just like opening a switch does. If the circuit is broken at any point, then no electric current will flow through any part of the circuit. In the past, Christmas tree lights were wired like this. When one bulb burned out, all the lights on the string went out.

This kind of a circuit is called a series circuit. For it to work there must be a continuous flow of current from one terminal of the battery to the other.

Exercise 17
Part 3

QUESTIONS

These questions refer to the diagram of the simple series circuit. Put a circle around the letter in front of the correct answer.

NOTE: Lights connected in series share the voltage. It is assumed in these questions that the voltage is such that none of the bulbs will burn out.

1. As the diagram is drawn, what must be done to make bulb 4 burn?

   A. Close both switches
   B. Close neither switch
   C. Close switch 1 only
   D. Close switch 2 only

2. With both switches closed and and bulb 4 removed

   A. only bulb 1 will burn.
   B. only bulbs 1 and 2 will burn.
   C. only bulbs 1, 2, and 3 will burn.
   D. no bulbs will burn.

3. If points D and G are connected directly by a wire, and switch 2 is closed

   A. only bulbs 1 and 2 will burn.
   B. only bulbs 3 and 4 will burn.
   C. all four bulbs will burn.
   D. no bulbs will burn.

4. If point D is connected to the negative terminal

   A. only one bulb will burn.
   B. only two bulbs will burn.
   C. only three bulbs will burn.
   D. all four bulbs will burn.

5. If point D is connected to point H, and switch 2 is closed

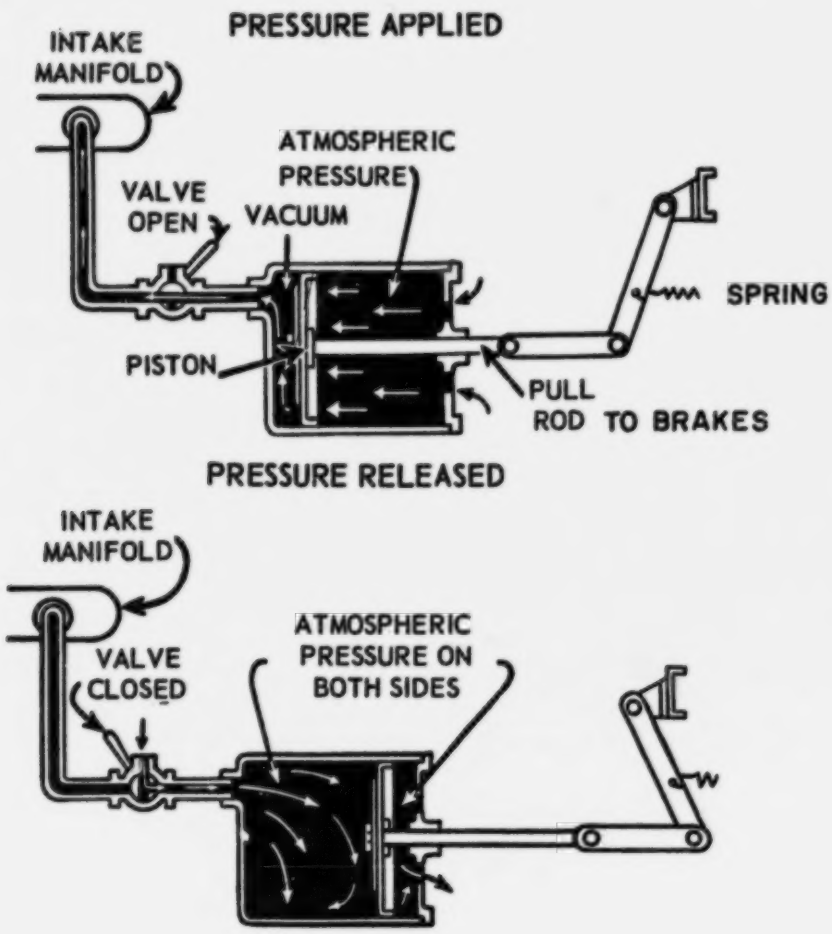
   A. only one bulb will burn.
   B. only two bulbs will burn.
   C. only three bulbs will burn.
   D. all four bulbs will burn.

6. Which of these actions will make only bulb 1 burn if wire BC is removed?

   A. Connect B and I
   B. Close switch 2
   C. Connect A and K
   D. Connect B and L

Exercise 17
Part 4

THE VACUUM POWER CYLINDER



The vacuum power system is used to operate power brakes on automobiles and trucks. These diagrams show how it operates. The vacuum power cylinder contains a piston. The piston is connected to a pull rod which operates the brakes.

The brake pedal operates the valve just to the left of the cylinder. When the valve is opened, air is exhausted from the cylinder to the left of the piston. The top picture shows the open valve.

Exercise 17
Part 4

Atmospheric pressure acts on the right side of the piston. Atmospheric pressure is the weight of the air in the atmosphere. Air weighs about 15 pounds per square inch at sea level. This pressure exerts a powerful force on the brakes. The area of the piston acted on by the atmospheric pressure decides the amount of braking effort.

The bottom picture shows the valve closed. The chamber to the left of the piston is shut off from the vacuum of the intake manifold. This valve lets air into the cylinder, releasing the piston and the brakes. The piston returns to its original (first) position by means of the spring seen on the right side of the drawing.

QUESTIONS

These questions refer to the diagrams of the vacuum power cylinder. Put a circle around the letter in front of the correct answer.

1. After the brake pedal pressure is applied, the valve is
   A. open.
   B. closed.

2. Air is exhausted from the right side of the cylinder by the return movement of the
   A. piston.
   B. manifold.

3. Air exhausted from the left side of the piston leaves the cylinder and goes to the
   A. pull rod.
   B. intake manifold.

4. When the valve is closed, there is atmospheric pressure on
   A. one side of the piston.
   B. both sides of the piston.

5. In the upper diagram, the white arrows stand for
   A. atmospheric pressure.
   B. the pumping of the piston.

6. The piston is moved to the right by
   A. atmospheric pressure.
   B. spring tension.

Exercise 18

SEEING THINGS IN THREE DIMENSIONS

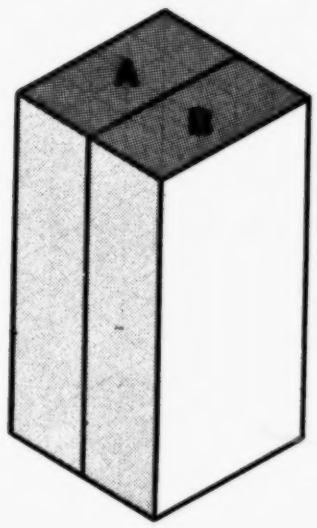
Brick Counting--Part 1)

Before doing this exercise go back and quickly review the exercises on Block Counting (Exercises 11 and 14 of Part B).

In this exercise you are to count the number of bricks in each drawing. It is important for you to remember that all the bricks used in this exercise are the same size.

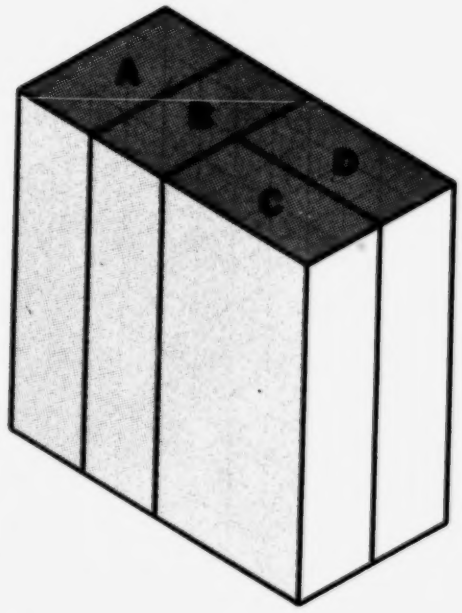
Example #1 shows two bricks (A and B). Both bricks are identical--that is, bricks A and B have the same height, width, and thickness.

EXAMPLE 1



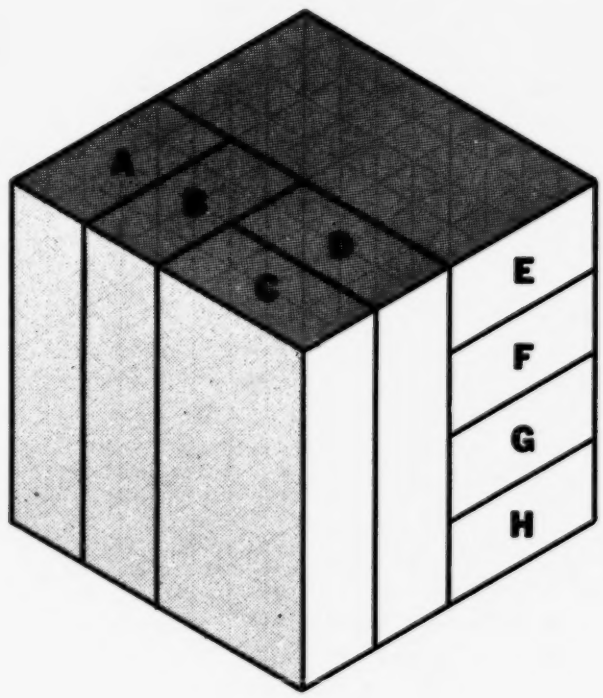
Example #2 has 4 bricks. Notice that bricks C and D touch brick B. This means that the long side of the top of brick B is twice as large as the short side of the tops of bricks C and D.

EXAMPLE 2



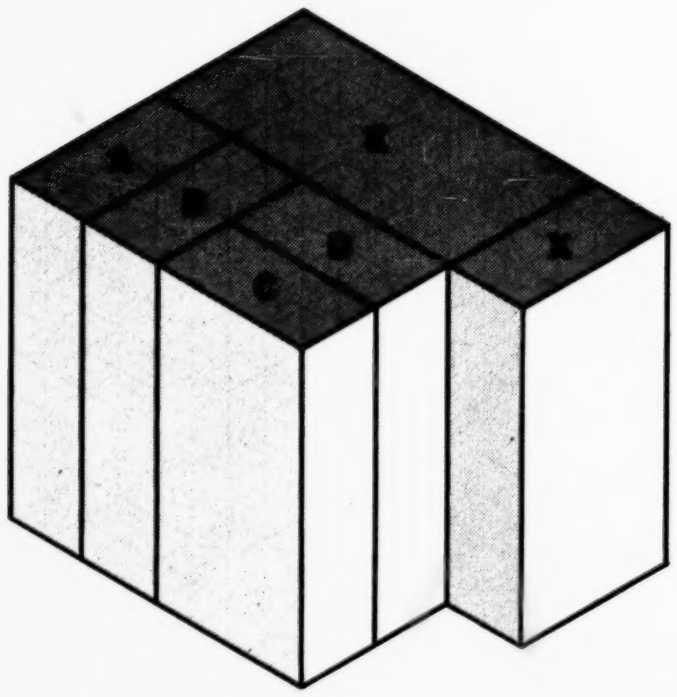
Example #3 is a picture of 8 bricks. Bricks E, F, G, and H touch bricks A, B, and D. The important rule to remember in this example is that each brick is four times as tall as it is thick.

EXAMPLE 3



How many bricks are in example #4?

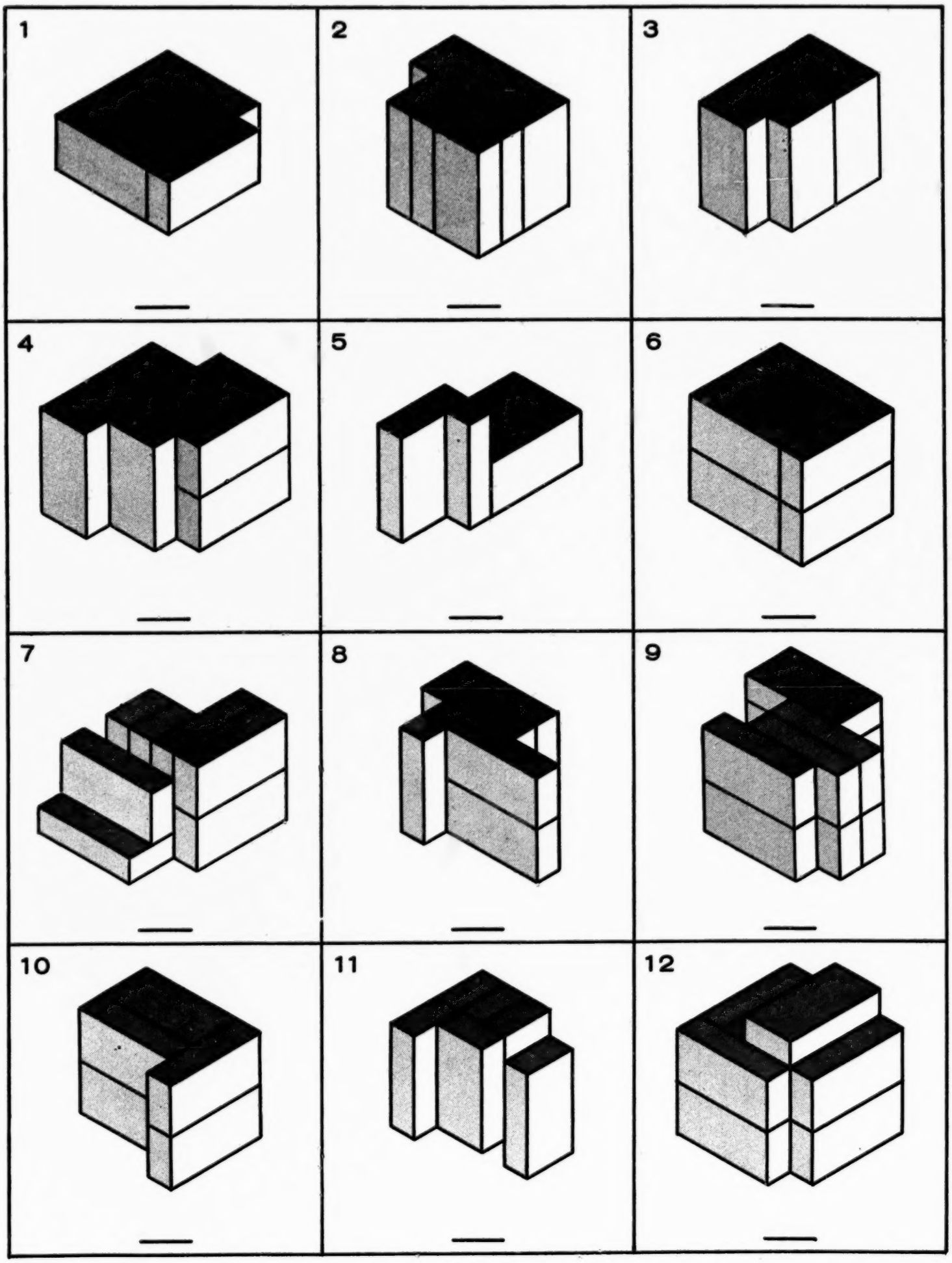
EXAMPLE 4



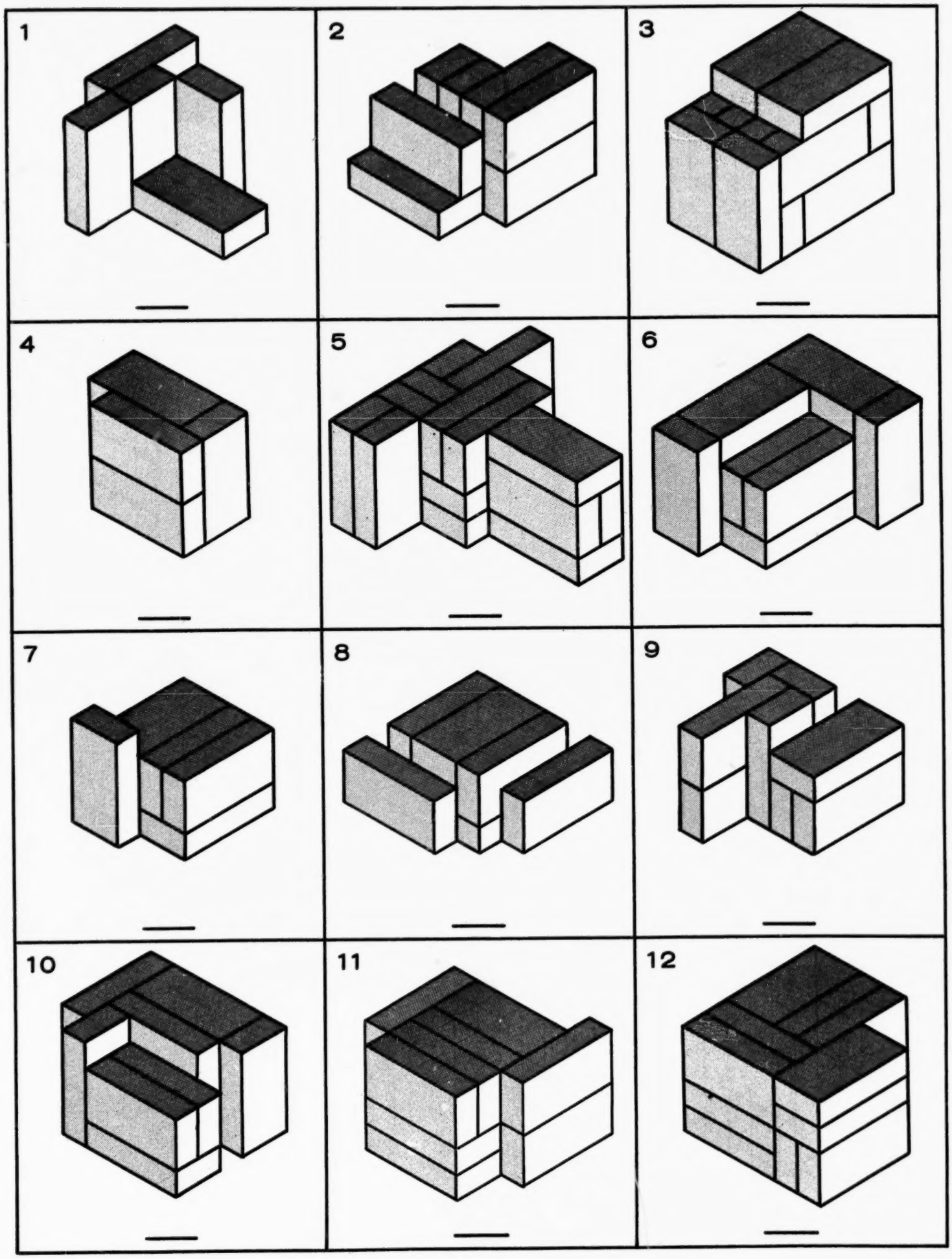
There are six bricks which you can see (A, B, C, D, E, and X), but you know that there are three more bricks under brick E (look at example #3). These three bricks cannot be seen because brick X is in the way. The answer is 9 bricks.

Directly under each problem there is a line. Put your answer on this line.

Drill 1



Drill 2



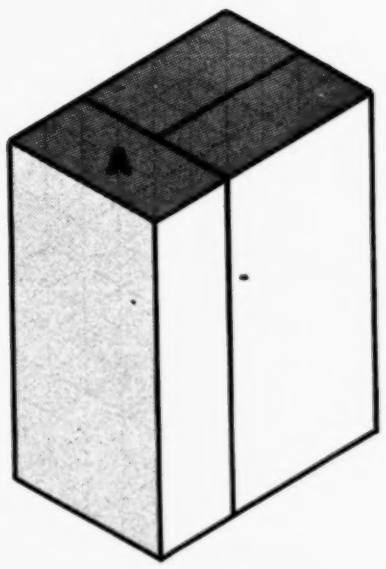
Exercise 18

SEEING THINGS IN THREE DIMENSIONS

(Brick Counting--Part 2)

In Part 1 of this exercise you learned to count all the bricks in each picture. In this part of the exercise the idea is to find how many bricks are touching lettered bricks. How many bricks are touching brick A in the example below?

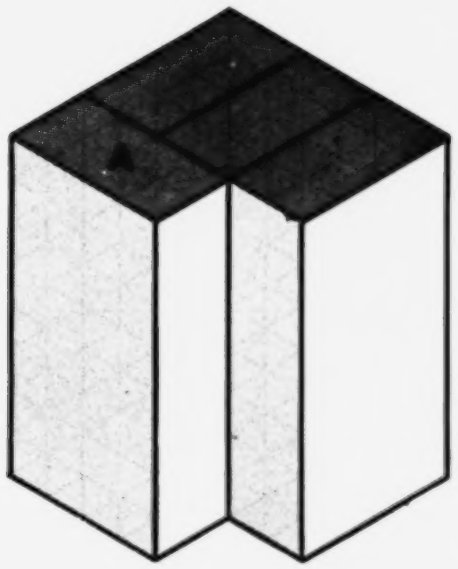
EXAMPLE 1



There are only 3 bricks in the picture and 2 bricks are touching A; therefore, the answer is 2 .

Do not count a brick because its edge touches a lettered brick. Study the example below and again find how many bricks are touching brick A.

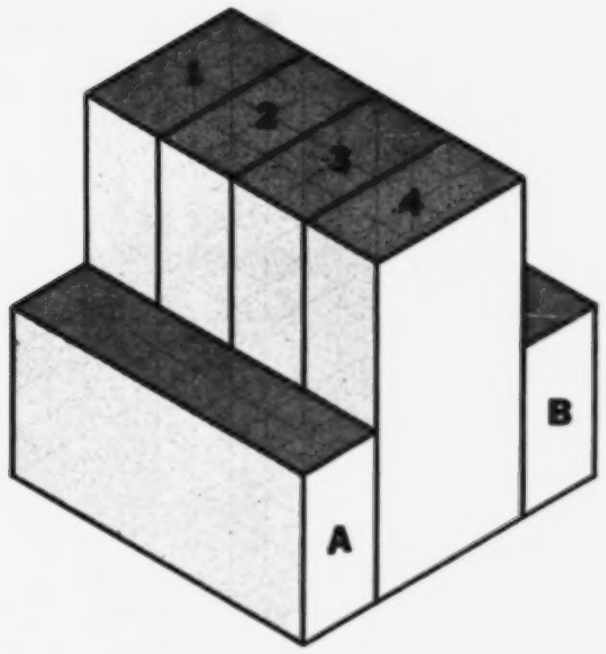
EXAMPLE 2



The answer to this problem is still 2 even though the edge of a third brick is touching brick A. Remember: never count a brick just because its edge touches a lettered brick.

In the next example, find how many bricks are touching brick A and then find how many bricks are touching brick B.

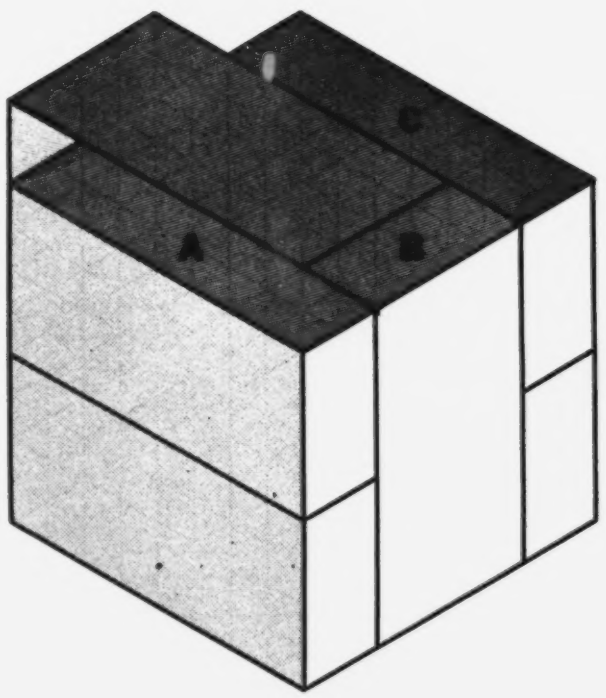
EXAMPLE 3



Bricks 1, 2, 3, and 4 are all touching brick A. The answer is 4. The answer to B is also 4. Even though you can see only brick #4 touching brick B, you know that bricks 1, 2, and 3 are also touching brick B.

The next example is exactly like the problems you will have to solve in this exercise. Find how many bricks are touching brick A and then brick B, and finally brick C. Put your answer to each question on the line to the right of each corresponding letter.

EXAMPLE 4



A ____

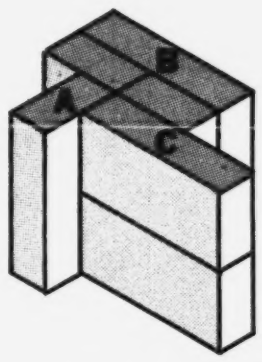
B ____

C ____

Brick A is touching 4 bricks. It is on top of one brick and it also touches brick B and two bricks behind B. Brick B touches 8 bricks. There are four bricks behind B and two on each side. B touches all of these bricks. Brick C is placed in the same way as brick A. It touches 4 bricks in the same way as A.

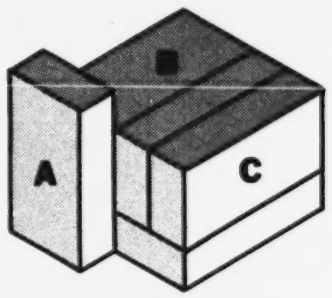
Drill 1

1



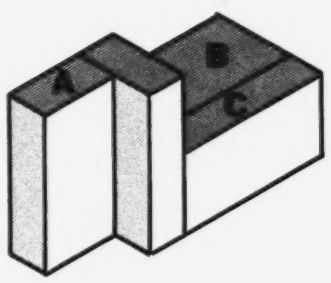
A___ B___ C___

2



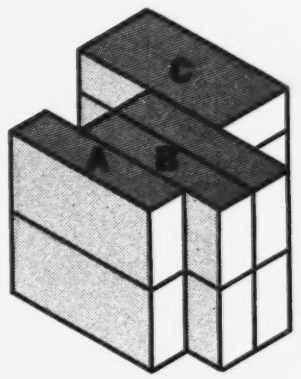
A___ B___ C___

3



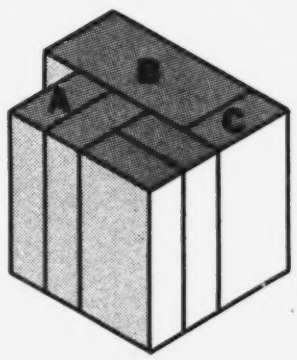
A___ B___ C___

4



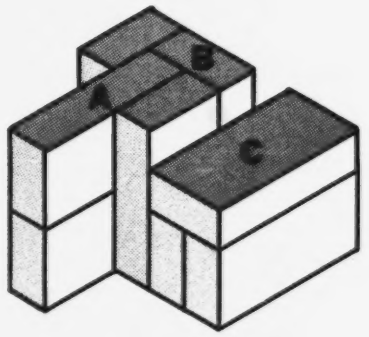
A___ B___ C___

5



A___ B___ C___

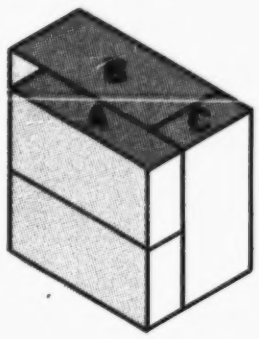
6



A___ B___ C___

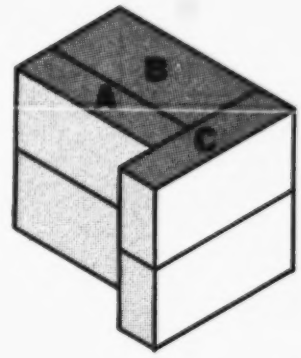
Drill 2

1



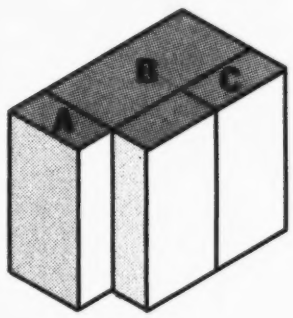
A____ B____ C____

2



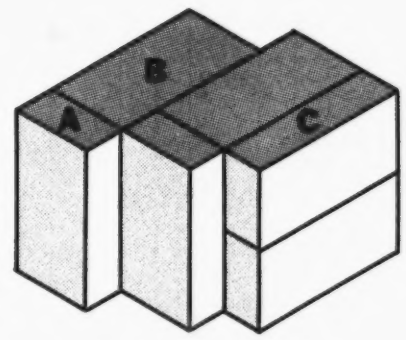
A____ B____ C____

3



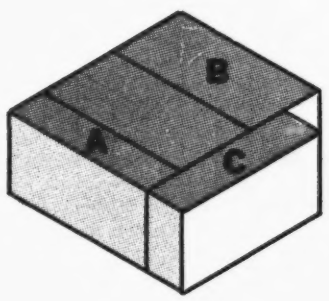
A____ B____ C____

4



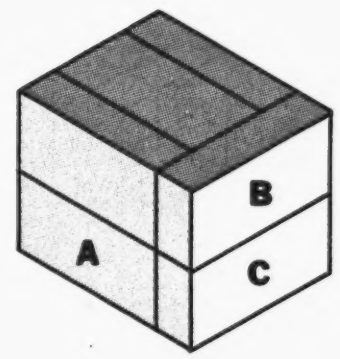
A____ B____ C____

5



A____ B____ C____

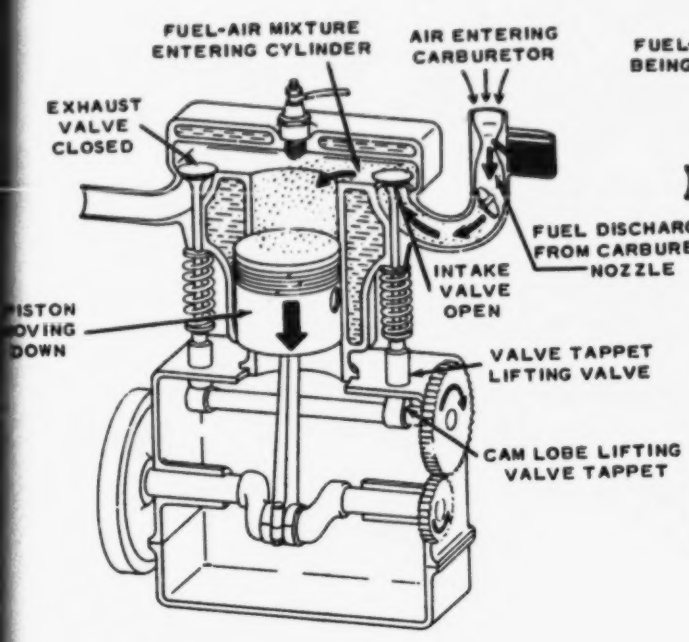
6



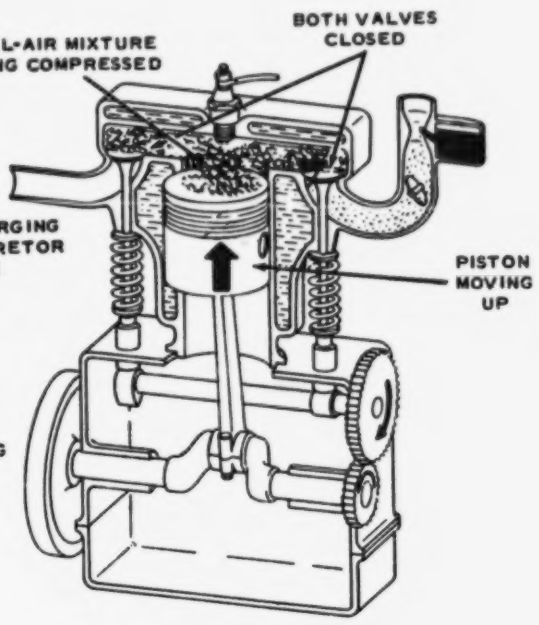
A____ B____ C____

Exercise 19
Part 1

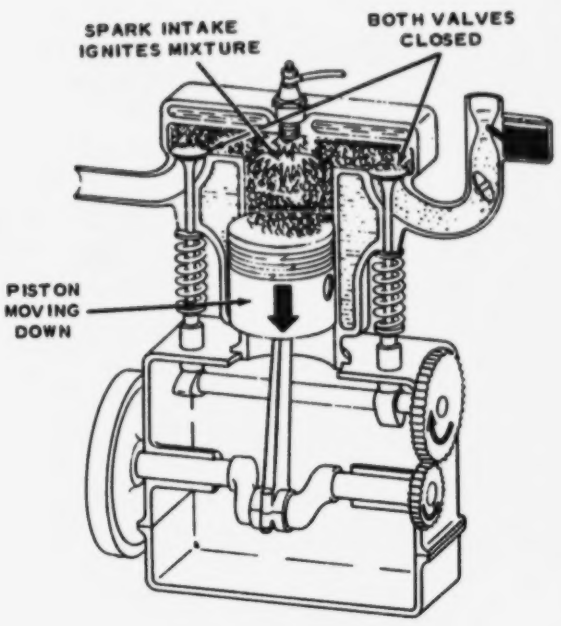
THE FOUR-CYCLE GASOLINE ENGINE



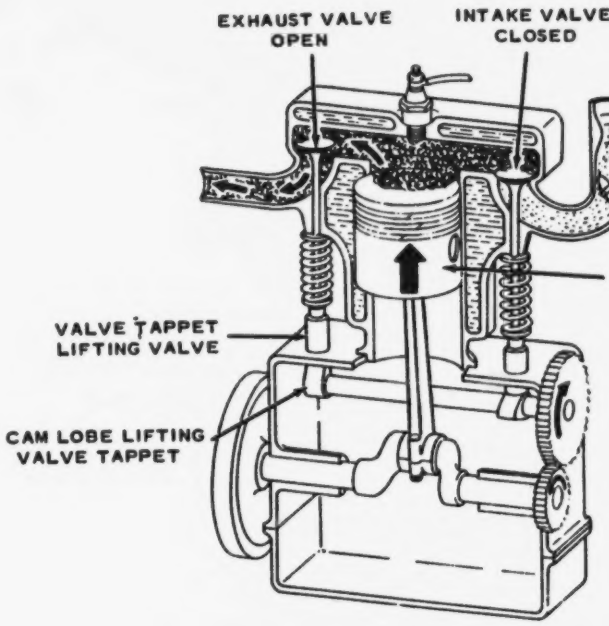
INTAKE



COMPRESSION



POWER



EXHAUST

The drawings show the four strokes in a four-cycle gasoline engine. The intake stroke brings the air-and-fuel mixture into the cylinder. The piston moves down and the intake valve opens. Air entering the carburetor mixes with fuel coming from the carburetor nozzle. This mixture goes into the cylinder through the open intake valve.

The compression stroke commences when the intake valve closes and the piston is pushed up into the cylinder. This presses (compresses) the mixture into a small space.

When the compression stroke ends, the power stroke begins. This is when the piston gets to the top of the cylinder and the mixture is ignited. The ignition system suddenly makes an electric spark in each cylinder in turn when the piston reaches this position. It is this spark that ignites (sets on fire) the mixture.

Exercise 19
Part 1

As the mixture burns, it expands greatly and this forces the piston back down. The force goes through the connecting rod to turn the crankshaft.

After the mixture of gas and air has burned, it must be removed from the cylinder. When the power stroke is finished, the piston moves up and the exhaust valve opens. The gases are then forced out of the cylinder as shown by the small black arrows in the bottom picture.

The engine is then ready for the intake stroke again. In a four-cycle engine with four cylinders a different stroke is going on in each cylinder at any one time.

QUESTIONS

These questions refer to the diagrams of the four-cycle gasoline engine. Put a circle around the letter in front of the correct answer.

1. Fuel and air enter the cylinder through the

   A. open intake valve.
   B. exhaust valve.
   C. piston.
   D. valve tappet.

2. When the piston moves up for the second stroke, the fuel-air mixture is

   A. pushed out.
   B. pulled in.
   C. compressed.
   D. exhausted.

3. An electric spark sets the mixture on fire, and the pressure from the expanding gases

   A. forces the piston up.
   B. pushes the piston to the side.
   C. opens the valves.
   D. pushes the piston down.

4. During the last stroke, the burned mixture

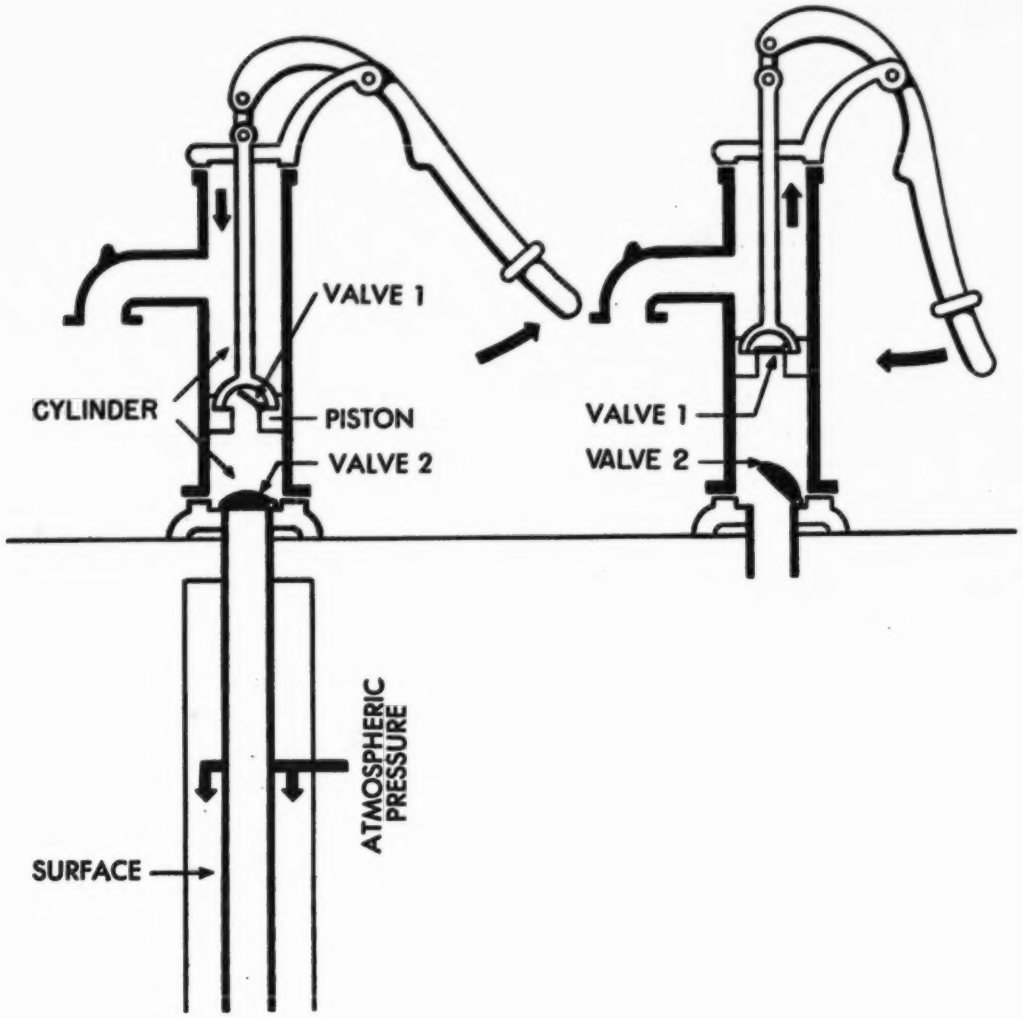
   A. pushes the piston down again.
   B. leaves the cylinder through the exhaust valve.
   C. leaves the cylinder through the intake valve.
   D. cannot escape.

5. Which one of the following is not one of the four strokes?

   A. Intake stroke
   B. Compression stroke
   C. Spark stroke
   D. Exhaust stroke

Exercise 19
Part 2

THE HAND PUMP



The diagram shows a hand pump for pumping water from a well. It raises water by producing a partial vacuum in the pipe to the well. A partial vacuum means that the air or water pressure inside the pipe is less than that of the air outside. The atmospheric pressure forces the water up the pipe by pressing down on the surface of the water in the well.

The pump handle is attached to a piston in which is mounted valve 1. At the bottom of the cylinder is valve 2.

Exercise 19
Part 2

When the handle of the pump is lifted, as in the left-hand picture, the piston goes down in the cylinder. When this happens, valve 1 opens and valve 2 closes. Then when the handle is pushed down, like in the right-hand picture, the piston goes up, which causes valve 1 to close and valve 2 to open. This is the pumping stroke when water comes out the spout of the pump.

If a pump made a perfect vacuum it could lift water 34 feet. The hand pump we have described usually can lift water about 25 feet because it can make only a partial vacuum.

This pump works on the same principle as sucking water through a straw. As you suck on the straw you create a partial vacuum in the straw. The weight or pressure of the atmosphere pushes the water up the straw by pressing down on the surface of the water in the container.

QUESTIONS

These questions refer to the diagrams of the hand pump. Put a circle around the letter in front of the correct answer.

1. Water comes out of the spout when
   - A. the piston is going down.
   - B. valve 1 is open.
   - C. the handle is going up.
   - D. the handle is going down.

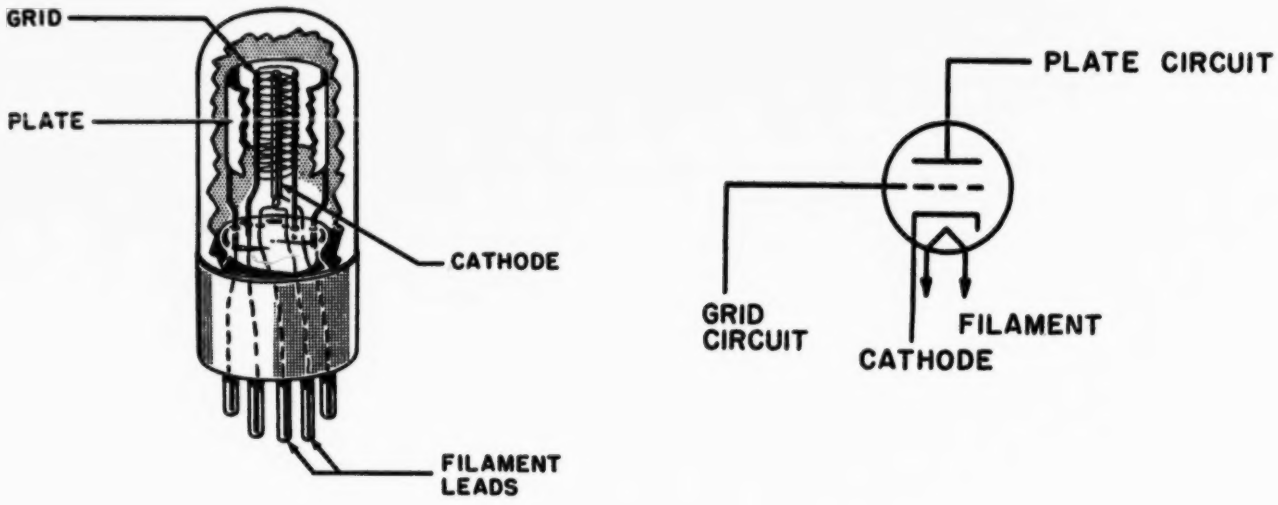
2. On the down stroke of the handle
   - A. valve 1 is closed and valve 2 is open.
   - B. valve 2 is closed and valve 1 is open.
   - C. both valves are closed.
   - D. both valves are open.

3. On the up stroke of the handle
   - A. valve 1 is closed and valve 2 is open.
   - B. valve 2 is closed and valve 1 is open.
   - C. both valves are closed.
   - D. both valves are open.

4. Water rises in the pipe below the pump when
   - A. the piston is going down.
   - B. the handle is going up.
   - C. the piston is going up.
   - D. valve 2 is closed.

Exercise 19
Part 3

A VACUUM TUBE



The vacuum tube pictured here is called a triode. The cutaway drawing shows how the parts actually look. The diagram shows how the parts work.

Triode means three elements. They are the cathode, the plate (or anode), and the grid. There is also a filament, used to heat up the cathode to make it give off electrons.

In the cutaway drawing the filament is shown in the middle of the cathode. The grid is the fine wire coil outside the cathode. The plate is outside the grid. This is sometimes called a vacuum tube because most of the air has been taken out of it.

The triode works like a valve. When the cathode is heated by the filament, current will flow between the cathode and the plate in only one direction. This happens when the cathode is negative and the plate is positive.

Exercise 19
Part 3

The grid acts to regulate this flow of electrons between the cathode and the plate. A weak fluctuating (or changing) current in the grid circuit controls a strong current between the cathode and anode. Thus the current which reaches the plate will be similar to but stronger than the original weak current.

This is how radio waves are amplified or made stronger.

QUESTIONS

These questions refer to the diagram of the vacuum tube. Put a circle around the letter in front of the correct answer.

1. The cathode is directly between the filament and the
   - A. antenna.
   - B. grid.
   - C. battery.
   - D. rectifier.

2. Current is weaker in the
   - A. grid.
   - B. cathode.

3. The air pressure in the tube is
   - A. greater than the outside air.
   - B. less than the outside air.
   - C. the same as the outside air.

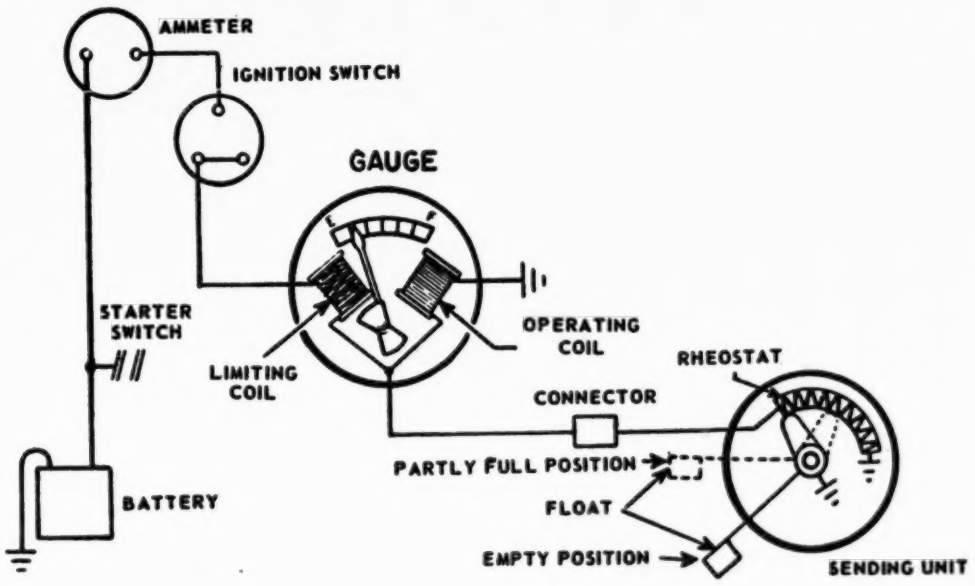
4. A weak radio signal that is to be amplified goes to the
   - A. filament.
   - B. cathode.
   - C. plate.
   - D. grid.

5. Heat is supplied by the
   - A. plate.
   - B. grid.
   - C. filament.
   - D. cathode.

6. The grid is directly between the cathode and the
   - A. plate (anode).
   - B. filament.
   - C. diode.
   - D. triode.

Exercise 19
Part 4

THE COIL-TYPE GAUGE CIRCUIT



The amount of gasoline in the gas tank of an automobile is shown by the fuel gauge. There are many types of fuel gauges. One of the most common is the coil type shown here. It is an electrical fuel gauge and usually works only when the ignition switch is on. You can see the ignition switch in the diagram. The power comes from the battery.

The sending unit that you see on the bottom right is located at the fuel tank. The sending unit has a float and arm assembly. The float and arm assembly is connected to the sliding contact of a rheostat.

As the level of the fuel in the tank changes, the position of the contact on a rheostat changes. The change in position causes circuit resistance to change. When circuit resistance changes, the current flow changes. This current is what makes the operating coil pull stronger or weaker than the limiting coil.

Exercise 19
Part 4

On the diagram, the dotted line shows the partly full position on the sending unit. The heavy line shows the empty position.

Notice that the gauge has two magnetic coils. One is the limiting coil. The other is the operating coil. The gauge also has a permanent magnet attached to the gauge needle. When the tank is empty, the limiting coil is stronger than the operating coil, drawing the magnet on the needle toward the limiting coil. The needle then points to "E" (empty).

QUESTIONS

These questions refer to the diagram of the coil-type gauge circuit. Put a circle around the letter in front of the correct answer.

1. When the tank is empty, which coil is stronger?

   A. Limiting coil
   B. Operating coil

2. When the operating coil has the stronger pull, the tank is

   A. empty.
   B. not empty.

3. A part of the gauge system which is located at the gas tank is the

   A. ammeter.
   B. rheostat.
   C. operating coil.
   D. limiting coil.

4. Current to the operating coil is caused to change by the

   A. connector.
   B. battery.
   C. ammeter.
   D. float and arm.

5. The rheostat is part of the

   A. limiting coil.
   B. operating coil.
   C. sending unit.
   D. fuel gauge.

Exercise 20

GETTING THE IDEA
(Abstract Reasoning--Part 6)

In doing Abstract Reasoning problems it is important to get the idea of what is happening. In Exercise 13, Part B of the Vocational Talent Exercises, you were given problems to do with series of numbers. Please go back to that exercise and review the instructions.

Sometimes the numbers in the series went up one at a time, or two, or three or more at a time. Sometimes the numbers went down in even steps. Other series went up or down an increasing amount.

You will find these same combinations again in the drills with this exercise.

You will also find another kind of series, where the differences go up or down in a pattern. Look at this series:

1, 2, 12, 13, 23, and so on

You will notice that the difference between the numbers is plus one, plus ten, plus one, and plus ten. When we continue this pattern, the next number would be one more than 23, or 24.

You will find that sometimes the numbers go down. When the same pattern is subtracted, the series will look like this:

50, 49, 39, 38, 28, and so on

The successive differences are minus one, minus ten, minus one, minus ten. In this example, the next number would be minus one again, or 27.

Other series of numbers may go up and down in the same series. Take the example below:

10, 15, 13, 18, 16, and so on

Here the successive differences are plus five, minus two, plus five, and minus two. This means that the next number will be 16 plus five, or 21.

It is suggested that in order to be sure of the pattern, you actually write in the difference between numbers, like this:

$15,^{+1}\ 16,^{+3}\ 19,^{+1}\ 20,^{+3}$ 23, and so on

Now for the drills:

Drill 1

Fill in the next number of the series in the space to the right.

1) 26, 29, 33, 38, 44, ____

2) 47, 42, 38, 35, 33, ____

3) 38, 37, 34, 29, 22, ____

4) 95, 94, 92, 89, 85, ____

5) 49, 49, 51, 51, 53, ____

6) 63, 60, 59, 56, 55, ____

7) 74, 75, 76, 77, 78, ____

8) 48, 51, 50, 53, 52, ____

9) 33, 28, 23, 18, 13, ____

10) 36, 35, 38, 37, 40, ____

11) 73, 72, 74, 73, 75, ____

12) 56, 65, 72, 77, 80, ____

13) 60, 62, 59, 61, 58, ____

14) 63, 63, 64, 64, 65, ____

15) 17, 18, 15, 16, 13, ____

16) 24, 29, 34, 39, 44, ____

17) 1, 11, 19, 25, 29, ____

18) 41, 44, 46, 49, 51, ____

19) 62, 65, 63, 66, 64, ____

20) 81, 78, 74, 69, 63, ____

21) 95, 94, 92, 91, 89, ____

22) 12, 16, 21, 27, 34, ____

23) 58, 74, 82, 86, 88, ____

24) 98, 95, 93, 90, 88, ____

25) 25, 22, 19, 16, 13, ____

26) 15, 20, 30, 45, 65, ____

27) 48, 46, 42, 36, 28, ____

28) 6, 8, 11, 13, 16, ____

29) 57, 55, 53, 51, 49, ____

30) 87, 87, 86, 86, 85, ____

31) 81, 83, 82, 84, 83, ____

32) 8, 10, 12, 14, 16, ____

Drill 2

Fill in the next number of the series in the space to the right.

1) 34, 27, 21, 16, 12, ____

2) 41, 41, 40, 40, 39, ____

3) 34, 18, 10, 6, 4, ____

4) 14, 15, 17, 21, 29, ____

5) 41, 39, 36, 34, 31, ____

6) 50, 53, 54, 57, 58, ____

7) 67, 68, 71, 76, 83, ____

8) 19, 20, 22, 23, 25, ____

9) 41, 39, 36, 32, 27, ____

10) 82, 82, 83, 83, 84, ____

11) 23, 24, 26, 29, 33, ____

12) 61, 63, 67, 73, 81, ____

13) 99, 89, 81, 75, 71, ____

14) 33, 30, 32, 29, 31, ____

15) 17, 15, 14, 12, 11, ____

16) 85, 80, 70, 55, 35, ____

17) 77, 76, 75, 74, 73, ____

18) 65, 59, 54, 50, 47, ____

19) 14, 12, 15, 13, 16, ____

20) 63, 69, 74, 78, 81, ____

21) 54, 57, 60, 63, 66, ____

22) 65, 62, 56, 47, 35, ____

23) 52, 50, 50, 48, 48, ____

24) 97, 98, 96, 97, 95, ____

25) 79, 83, 87, 91, 95, ____

26) 69, 74, 78, 81, 83, ____

27) 33, 29, 25, 21, 17, ____

28) 70, 61, 54, 49, 46, ____

29) 17, 19, 22, 26, 31, ____

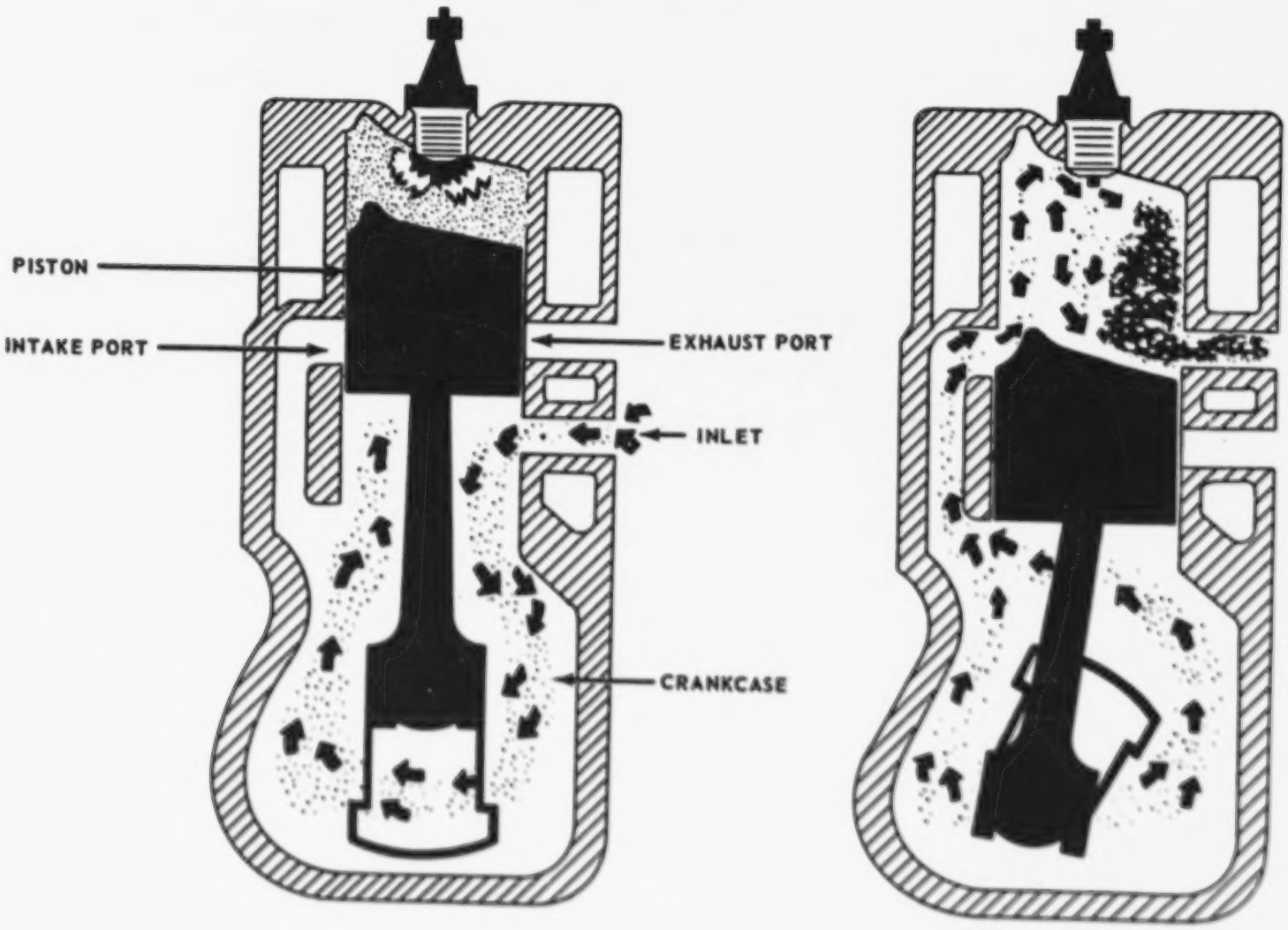
30) 31, 28, 29, 26, 27, ____

31) 44, 47, 53, 62, 74, ____

32) 9, 11, 12, 14, 15, ____

Exercise 21
Part 1

THE TWO-CYCLE ENGINE



This diagram shows how one type of two-cycle gasoline engine works. The two-cycle engine needs only two piston strokes instead of four like most automobile engines. Two-cycle gasoline engines are used for outboard motors, lawn mowers, lightweight motorcycles, etc.

The left-hand picture shows the start of the power stroke. The spark plug has just ignited the compressed fuel-and-air mixture. As the piston comes down it covers the inlet. A fraction of a second later the exhaust port is uncovered, letting the burned gases out. Slightly later the intake port is uncovered by the moving piston and the fuel-and-air mixture moves up around the piston from the crankcase.

Exercise 21
Part 1

The intake port is still open as the piston starts back up. This is shown in the right-hand picture. The shape of the top of the piston helps direct the incoming mixture up into the cylinder.

As the piston moves back up, several things happen. First the intake port is closed by the top of the piston. Then the inlet is opened by the bottom of the piston. Then the exhaust port is covered by the cylinder. Next the piston compresses the fuel-and-air mixture above it, and finally more fuel-and-air mixture is sucked into the crankcase through the inlet.

When the piston reaches the top of its stroke, the spark plug is fired, starting the process all over again.

Notice that there are no valves in the cylinder head of this engine like there are in a four-cycle engine.

QUESTIONS

These questions refer to the diagram of the two-cycle engine. Put a circle around the letter in front of the correct answer.

1. When the piston moves up, the fuel and air enter the crankcase through the
   - A. exhaust port.
   - B. intake port.
   - C. cylinder.
   - D. inlet.

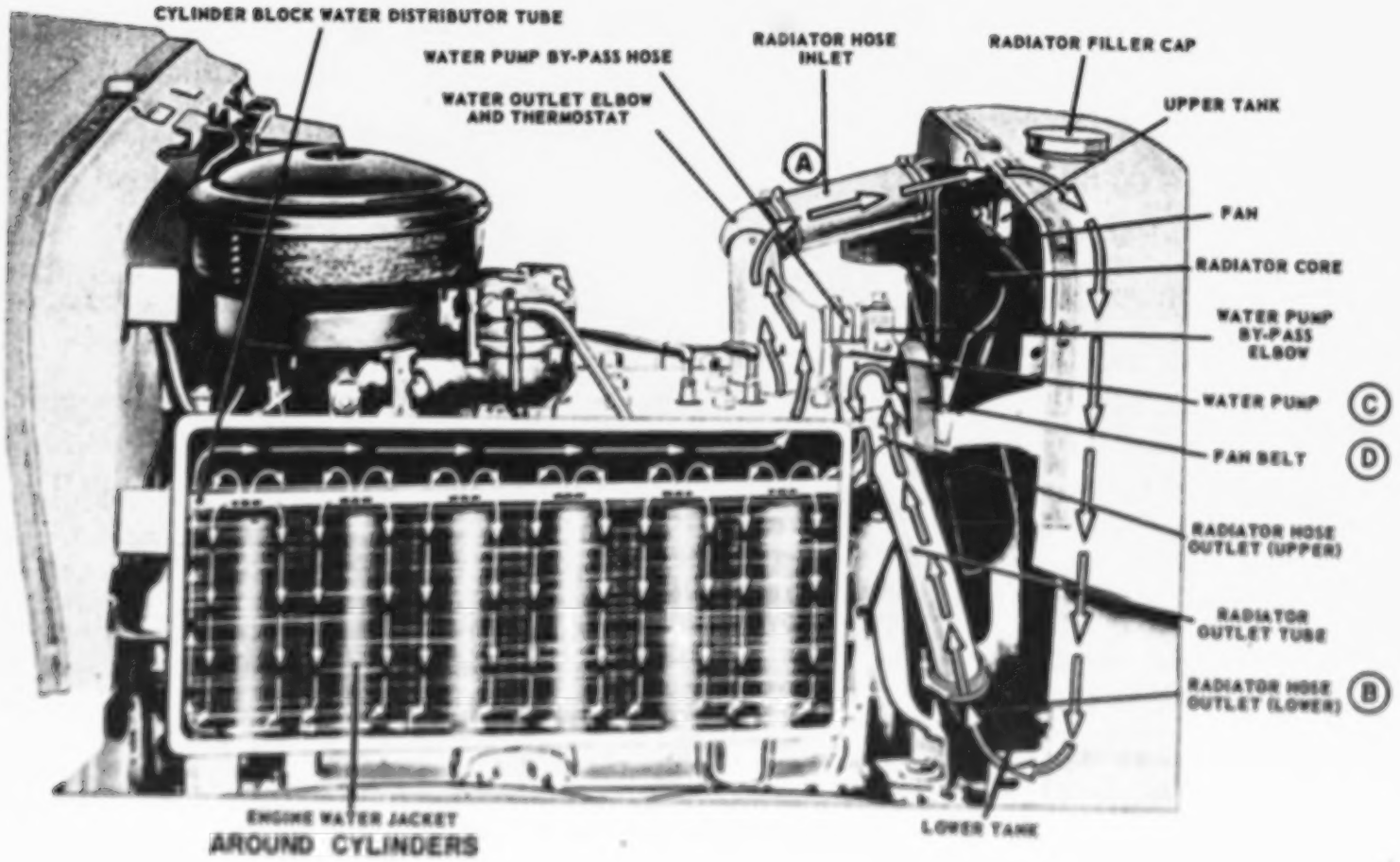
2. The fuel-air mixture enters the cylinder through the
   - A. intake port.
   - B. inlet.
   - C. intake valve.
   - D. exhaust port.

3. Once the mixture has been burned, it goes out through
   - A. the inlet.
   - B. the intake port.
   - C. the crankcase.
   - D. the exhaust port.

4. After the spark plug fires on the power stroke, the first port to open is the
   - A. intake port.
   - B. inlet.
   - C. exhaust port.
   - D. none of the above.

Exercise 21
Part 2

A LIQUID COOLING SYSTEM FOR AUTOMOBILE ENGINES



Most automobile engines use a liquid system like the one shown here. A cooling system carries away the heat of combustion from the cylinders.

Any liquid that is used in a liquid cooling system is called a coolant. Most liquid cooling systems work by circulating the coolant around the hottest parts of the engine. These hottest parts are the cylinder block and the cylinder head.

The coolant is pumped through the passages of the cylinder block and up into the cylinder head. The coolant leaves the cylinder head through an opening or outlet at the top.

Exercise 21
Part 2

The coolant then leaves the engine and goes through an upper hose connection to the radiator. A stream of air helps remove the heat from the coolant. The air is forced through the radiator both by the fan and by the forward motion of the automobile.

The coolant goes through an outlet tube to the water pump. The water pump forces the coolant through the cylinder block, starting the cycle all over again. The arrows show the path taken by the coolant.

QUESTIONS

These questions refer to the diagrams of the liquid cooling system for automobile engines. Put a circle around the letter in front of the correct answer.

1. In the diagram, the water jacket is shown covering
   - A. the lower tank.
   - B. the fan belt.
   - C. the cylinders.
   - D. the radiator hose.

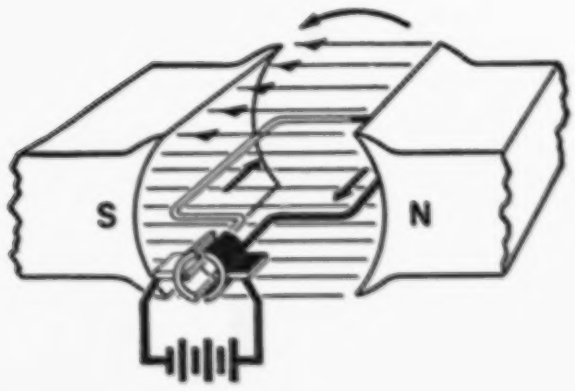
2. The arrows in the diagram
   - A. show how the heat from the engine travels.
   - B. show how the coolant travels.
   - C. point out the parts of the engine and radiator.
   - D. show how the fan moves.

3. As the coolant circulates, it enters the radiator
   - A. at point A.
   - B. at point B.
   - C. at point C.
   - D. at point D.

4. When it leaves the radiator, the coolant goes to
   - A. the water pump.
   - B. the upper tank.
   - C. the fan.
   - D. the thermostat.

Exercise 21
Part 3

A SIMPLE DIRECT CURRENT MOTOR



Without magnetism an electric motor would not work. It works because of the reaction of the magnetic field of the armature to the magnetic field of the field coil. The field coil is the fixed part of the electric motor and the armature is the part that turns.

Current from the battery enters the coil through one of the brushes and one of the commutator segments, and leaves through the other commutator segment and the other brush. As the current flows through the coil it makes a magnetic field around the wires of the coil. The magnetic field reacts against the magnetic lines of flux, causing the armature coil to turn one-half turn.

When the armature coil has turned half way the current is changed by the commutator. The part of the commutator which was positive before now becomes negative, and the part that was negative becomes positive. This makes the current run in the other direction in the coil, causing the coil to take another half turn. The commutator causes the direction of the current to reverse again, keeping the motor armature turning as long as there is current being supplied.

Exercise 21
Part 3

This is a very simple electric motor. More complicated ones have many more coils and many more segments to the commutator. Some of them have many more field coils also.

QUESTIONS

These questions refer to the diagram of the simple direct current motor. Put a circle around the letter in front of the correct answer.

1. In an electric motor, which part does the electric current flow through?

   A. The field coil
   B. The magnetic lines of flux
   C. The armature coil
   D. The stator

2. Which way does the current flow through the armature coil?

   A. Clockwise (↻)
   B. Counterclockwise (↺)
   C. It changes direction as the armature rotates.
   D. There is no way of knowing.

3. Which of the following things rotate with the armature as it turns around?

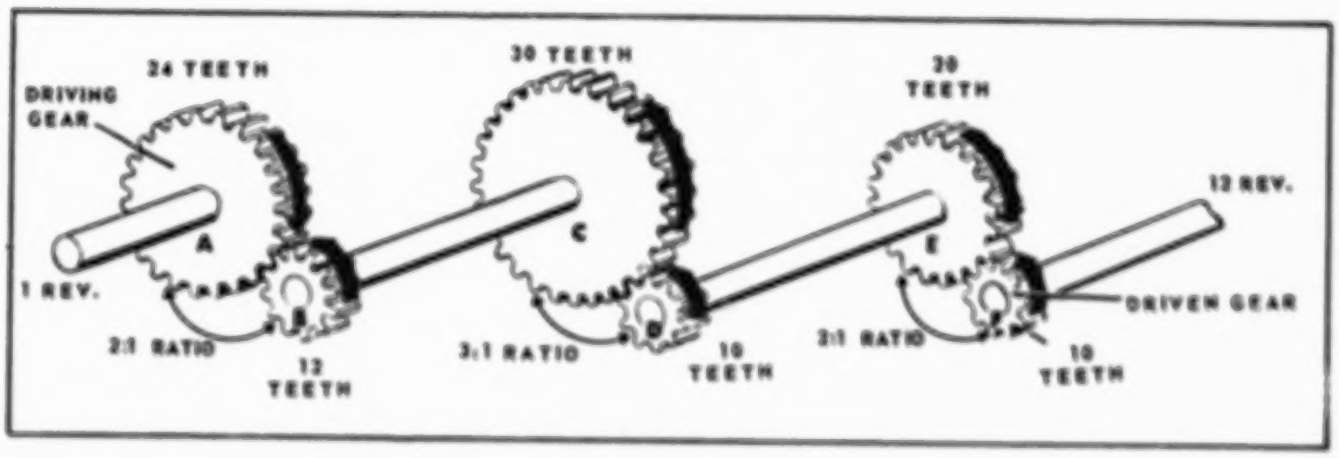
   A. The brushes
   B. The commutator
   C. The battery
   D. The field coil

4. In the diagram, which way is the armature moving?

   A. Clockwise
   B. Counterclockwise
   C. From left to right
   D. From right to left

Exercise 21
Part 4

A GEAR TRAIN



The picture shows six spur gears mounted on four shafts. The number of teeth in each spur gear is shown. Also shown are the speed ratios for the various pairs of gears.

Because gear B has half as many teeth as gear A, gear B will have to turn twice for every turn of gear A. Gear C also turns twice for every turn of A because it is fixed to the same shaft as gear B.

Gear D will turn three times as fast as gear C because it has only one third the number of teeth. That means that while gear A makes one turn, gears B and C will make two turns, and gear D will make six turns. Gear E will also make six turns for every turn of gear A because it is fixed to the same shaft as gear D.

Gear F will turn twice for every turn of gear E because it is only half as big. This means that for every turn of gear A, gear F will turn twelve times.

Exercise 21
Part 4

Like spur gears in simple gear trains, meshing gears move in the opposite direction. That means that when gear A turns clockwise, gears B and C turn counterclockwise, gears D and E turn clockwise, and gear F turns counterclockwise.

QUESTIONS

These questions refer to the diagram of gear trains. Put a circle around the letter in front of the correct answer.

1. Which of the following gears moves fastest?

   A. Gear A
   B. Gear C
   C. Gear E
   D. Gear F

2. Which gear moves at the same speed as gear E?

   A. Gear A
   B. Gear B
   C. Gear D
   D. Gear F

3. Which gear always turns in the same direction as gear A?

   A. Gear B
   B. Gear C
   C. Gear E
   D. Gear F

4. What is the speed ratio between gears A and C?

   A. 2 to 1
   B. 3 to 1
   C. 6 to 1
   D. 12 to 1

5. What is the speed ratio between gears B and E?

   A. 2 to 1
   B. 3 to 1
   C. 6 to 1
   D. 12 to 1

6. From the picture, what is this gear train designed to do?

   A. Decrease speed
   B. Increase speed
   C. Increase power
   D. You cannot tell

Exercise 22

SEEING THINGS IN THREE DIMENSIONS

(3-D Visualization--Part 3)

The drills in this exercise are a continuation of the 3-D visualization problems contained in Part A.

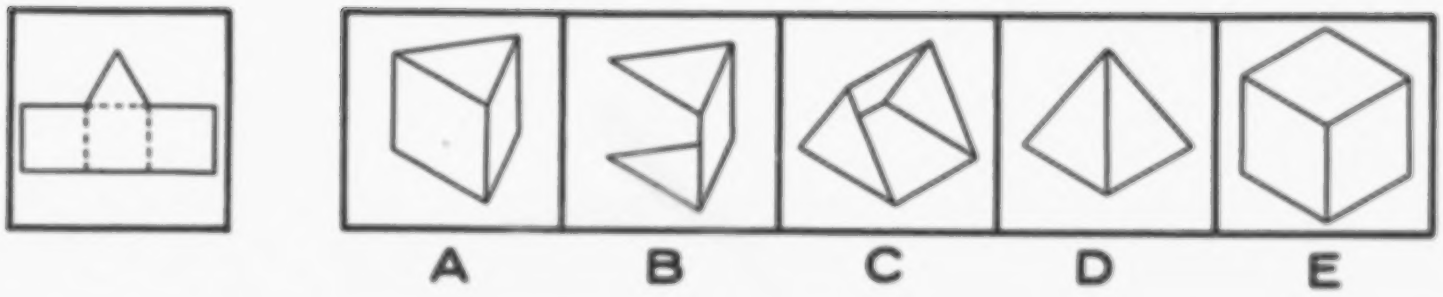
For each problem in this exercise, there will be a drawing of a flat piece of metal at the left. There are five objects at the right. Only one of the objects shown can be made from the piece of metal.

Select the object that can be made from the piece of metal. The solid lines show how the metal is cut. The dotted lines show how the metal is to be folded. No parts overlap. No parts are folded inside of other parts.

When your teacher tells you, turn the page and start the exercise. Circle the letter under the box containing the correct drawing.

Drill 1

1



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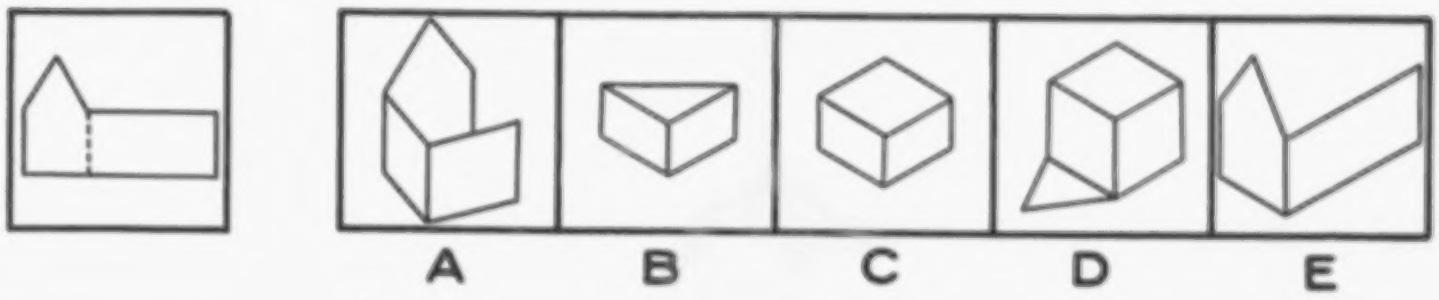

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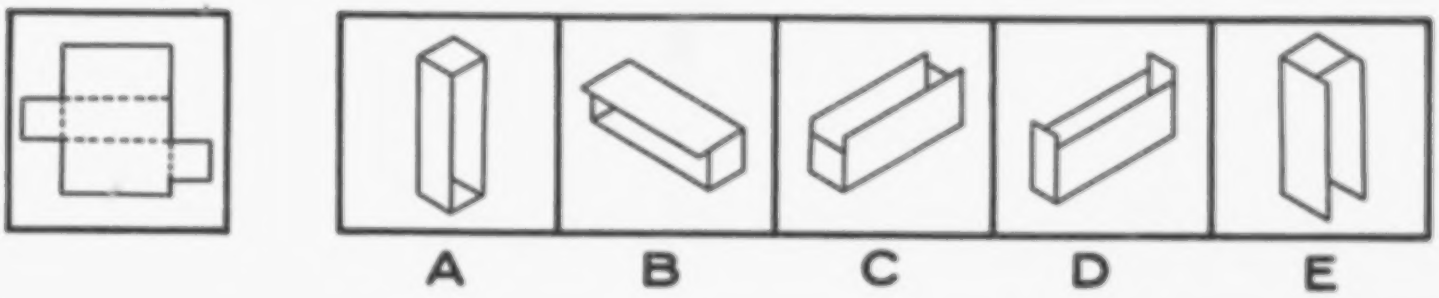

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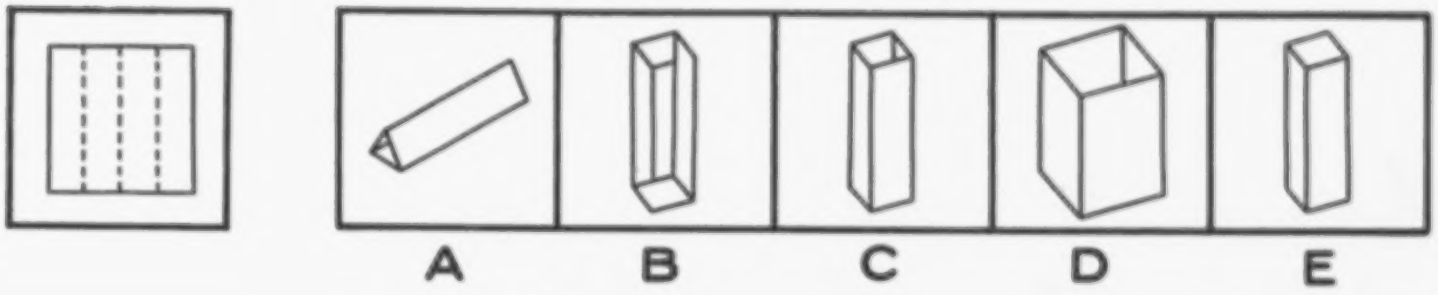

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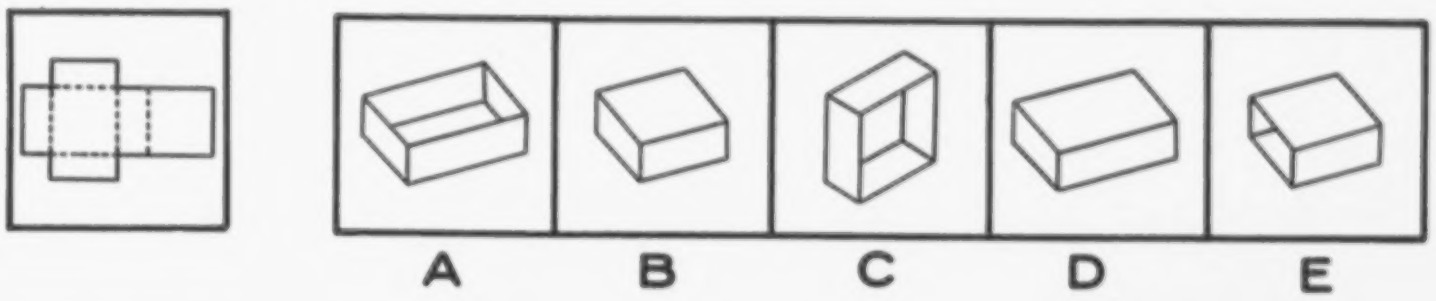

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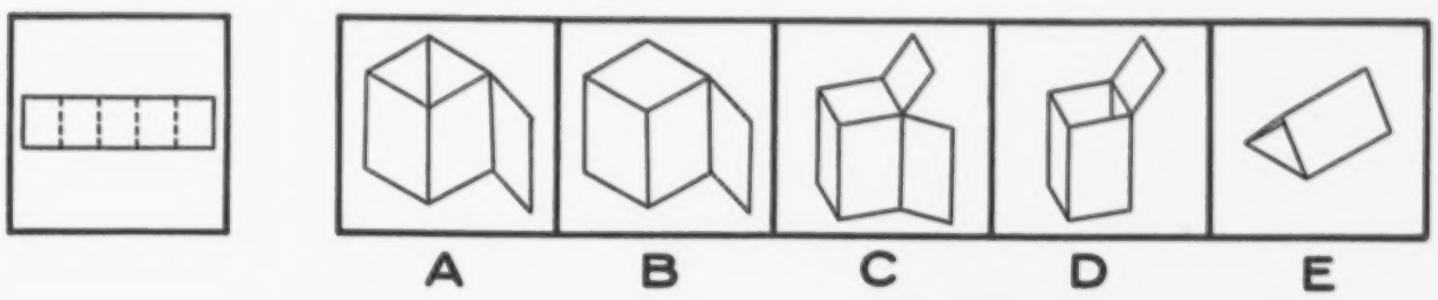

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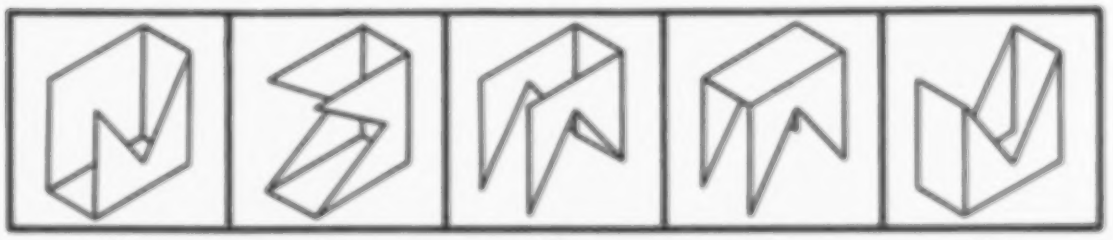
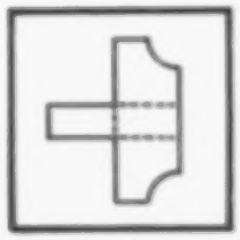
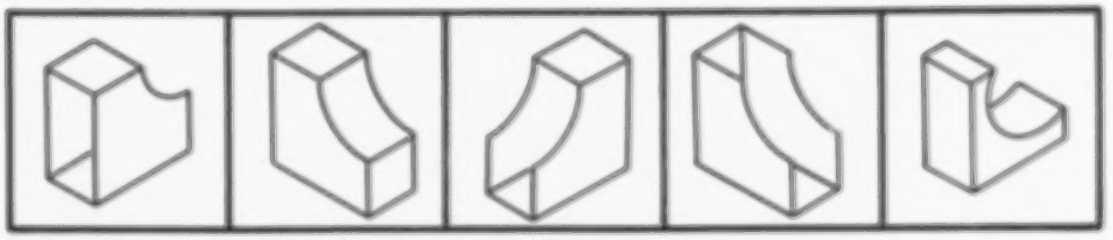


A B C D E

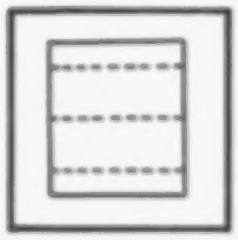
8

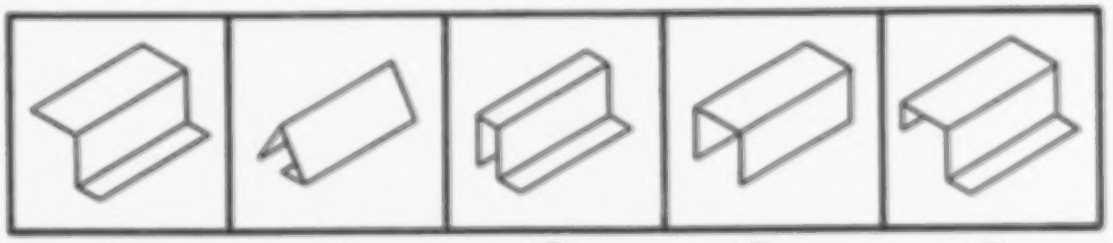




A B C D E

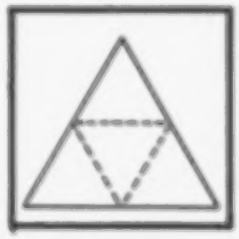
9





A B C D E

10



A B C D E

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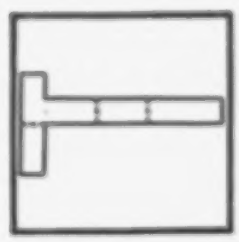

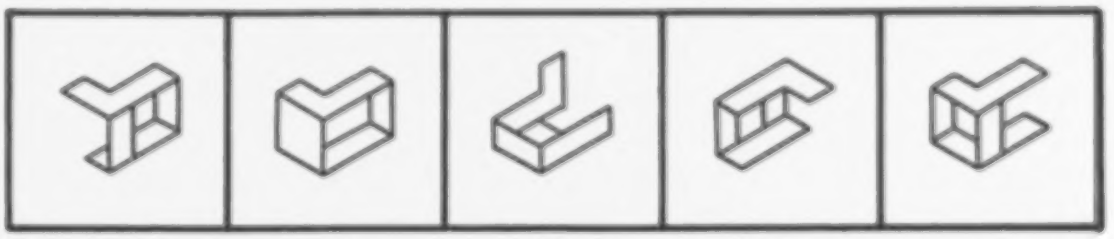

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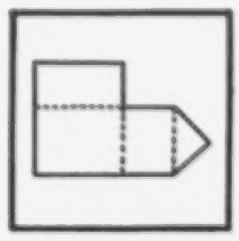

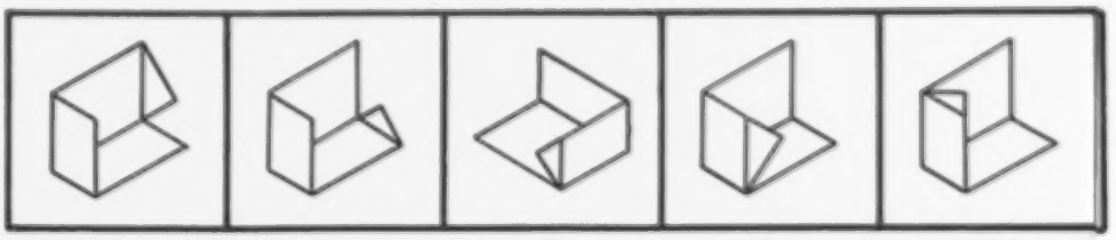

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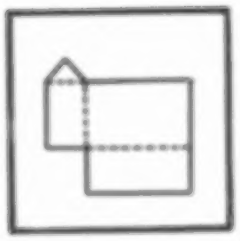
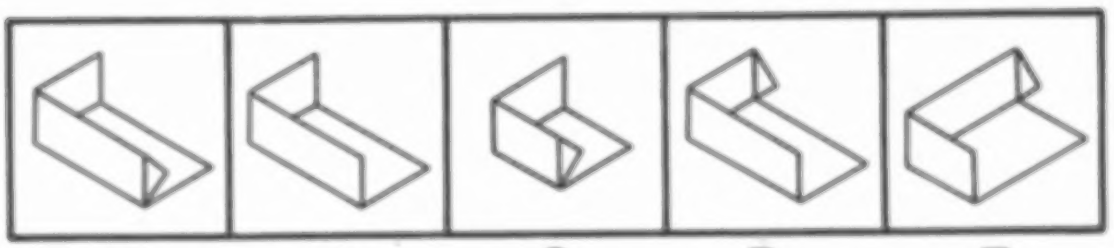
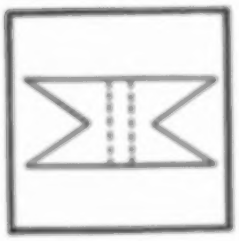
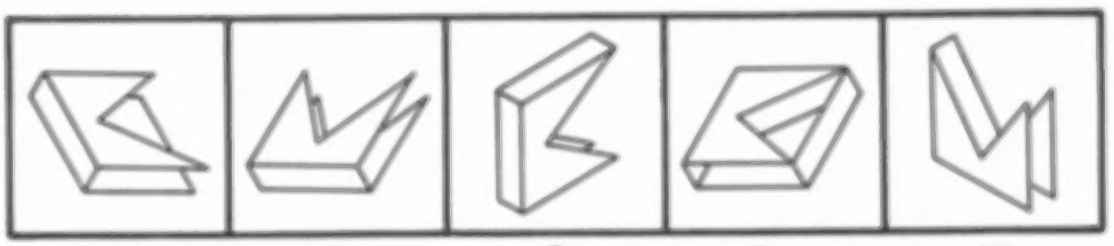




A B C D E

14





A B C D E

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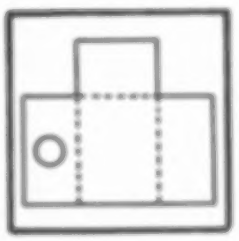
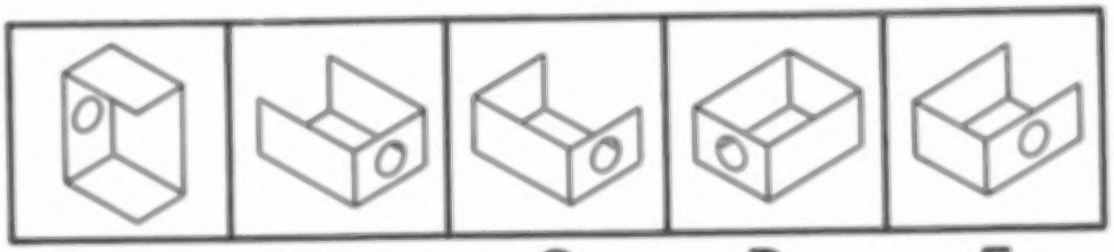
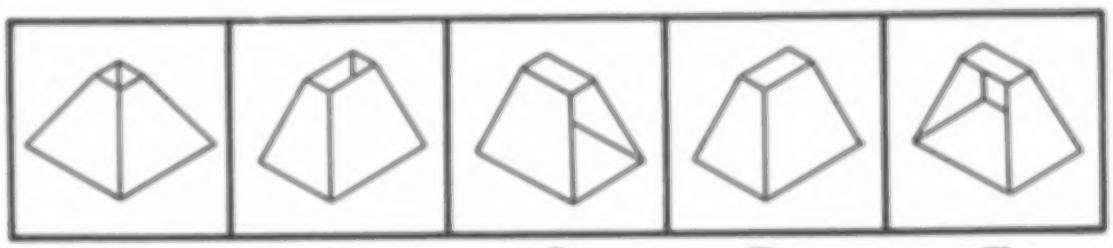




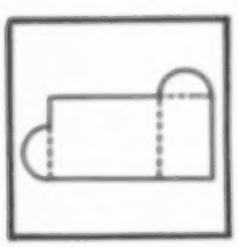
A B C D E

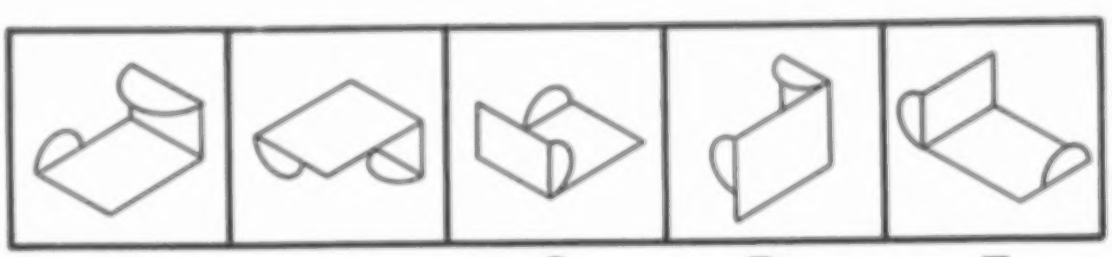
16



A B C D E

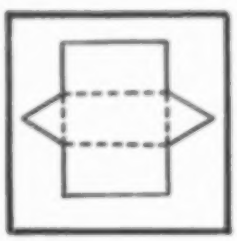
17

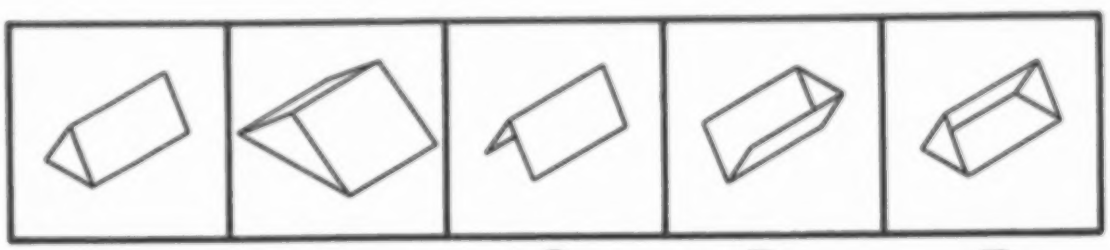




A B C D E

18

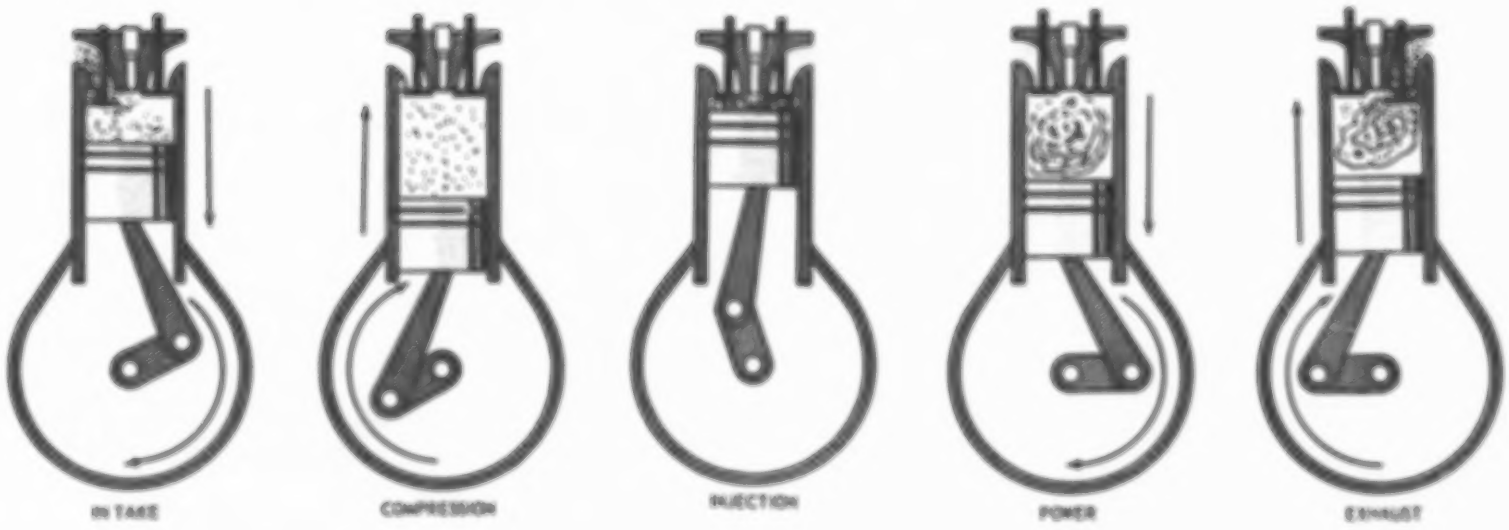




A B C D E

Exercise 23
Part 1

THE FOUR-CYCLE DIESEL ENGINE



These drawings show the operation of a four-cycle diesel engine. The four strokes (or cycles) are the intake stroke, the compression stroke, the power stroke, and the exhaust stroke. These are very much like the four strokes of a four-cycle gasoline engine.

The diesel engine does not have a carburetor. Only air enters the cylinders on the intake stroke. In the left drawing you can see the open intake valve where the air goes into the cylinder from the left.

On the compression stroke, squeezing the air into a small space causes it to get very hot. The second drawing shows the piston moving up to compress the air. The compression is much greater in a diesel engine than in a gasoline engine.

Next, fuel is injected into the cylinder. The middle drawing shows the fuel being injected into the very hot compressed air. The heat ignites (sets on fire) the fuel-and-air mixture.

Exercise 23
Part 1

In the gasoline engine, a spark from a spark plug is used to ignite the fuel-and-air mixture. The diesel engine does not need a spark plug. The hot air and the diesel fuel ignite just by coming in contact with each other.

In burning, the mixture gets very hot and tries to expand in all directions. The next drawing shows the piston being pushed down by the pressure from the burning fuel. This stroke is the power stroke.

The right-hand drawing shows the exhaust stroke. Notice that the piston is moving up again. The burned mixture is forced out through the open exhaust valve.

QUESTIONS

These questions refer to the diagrams of the four-cycle diesel engine. Put a circle around the letter in front of the correct answer.

1. During the power stroke, the piston is forced down by
   - A. the flywheel.
   - B. the pressure from the burning fuel-and-air mixture.
   - C. The injection of fuel.
   - D. the cooling of the air.

2. The fuel is injected
   - A. on the intake stroke.
   - B. before the compression stroke.
   - C. just after the air is compressed.
   - D. after the power stroke.

3. Which way does the piston move on the intake stroke?
   - A. Clockwise
   - B. Counterclockwise
   - C. Up
   - D. Down

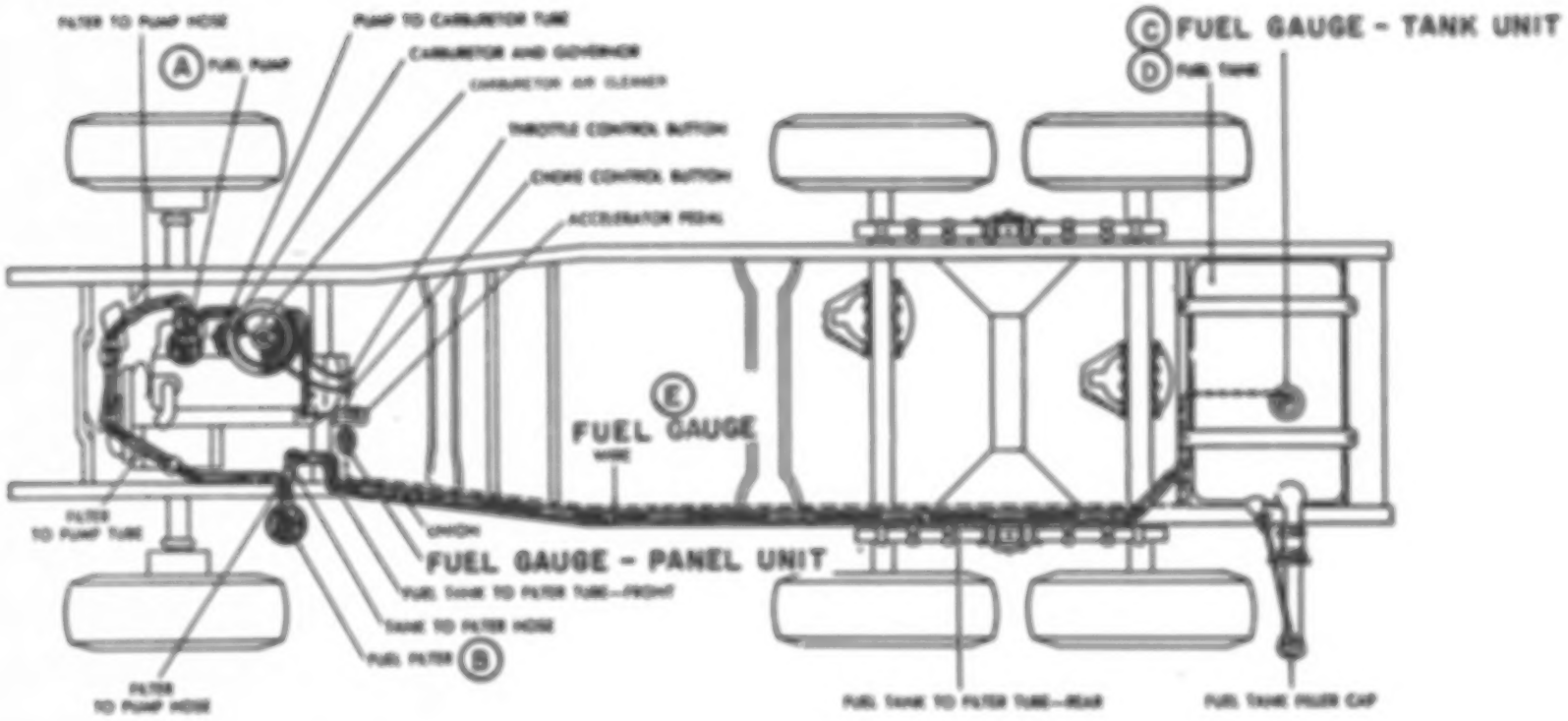
4. Which way does the piston move on the compression stroke?
   - A. Clockwise
   - B. Counterclockwise
   - C. Up
   - D. Down

5. When the fuel is injected
   - A. both valves are closed.
   - B. both valves are open.
   - C. only the intake valve is open.
   - D. only the exhaust valve is open.

6. What enters the cylinder on the intake stroke?
   - A. Fuel-and-air mixture
   - B. Fuel only
   - C. Air only
   - D. Neither fuel nor air

Exercise 23
Part 2

A GASOLINE ENGINE FUEL SYSTEM



This diagram shows the fuel system for a six-wheel truck. It is very similar to the fuel system on most gasoline-driven vehicles.

The main parts of the system are the fuel tank, fuel gauge, fuel line, fuel filter, fuel pump, carburetor, air cleaner, controls, etc. All of these parts are needed to supply the engine with a combustible mixture of gasoline and air.

You can follow the flow of the gasoline through the system by following the arrows in the diagram. The dotted line shows how the electrical wiring runs which connects the tank unit and the panel unit of the fuel gauge. In this fuel gauge system there is a fuel gauge dial on the instrument panel and a measuring unit at the tank.

Exercise 23
Part 2

QUESTIONS

These questions refer to the diagram of the gasoline engine fuel system. Put a circle around the letter in front of the correct answer.

1. The supply of fuel is stored at

   A. point A.
   B. point B.
   C. point C.
   D. point D.

2. The drawing shows a fuel gauge on the

   A. fuel pump.
   B. instrument panel and another on the fuel tank.
   C. fuel filter.
   D. pump tube.

3. The fuel gauge panel unit and the fuel gauge tank unit are joined by a

   A. filter tube.
   B. union.
   C. hose.
   D. wire.

4. When it leaves the fuel pump, the fuel goes to the

   A. fuel filter.
   B. fuel tank.
   C. tube to the carburetor.
   D. tank filter cap.

5. Which of the following is not connected directly to the carburetor?

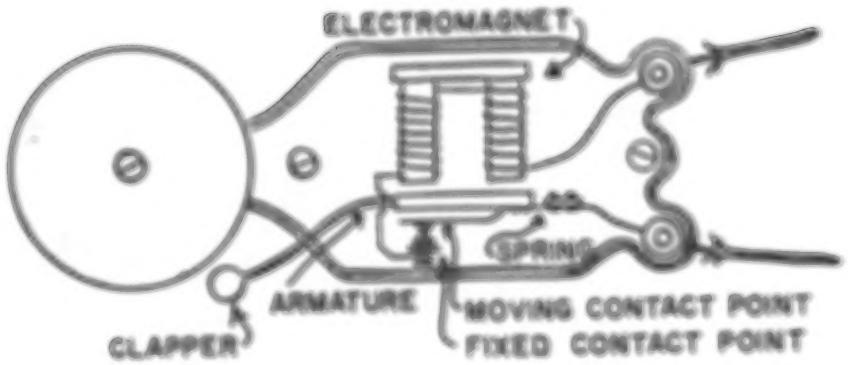
   A. Throttle control button
   B. Choke control button
   C. Accelerator pedal
   D. Union

6. Which of the following gasoline tubes is divided into two parts?

   A. Fuel tank to filter tube
   B. Filter to pump tube
   C. Pump to carburetor tube
   D. None of the above

Exercise 23
Part 3

A SIMPLE DOOR BELL



Most simple door bells are made very much like the picture here. They all have an electromagnet, an armature with a clapper attached, and a contact point.

When someone presses the door bell button, current flows in the wire through the electromagnet. This draws the armature toward it. The clapper strikes the bell as the armature moves.

However, something else happens when the armature moves. One side of the contact point is also attached to the armature. When the armature moves, this contact point opens. This breaks the flow of current going to the electromagnet.

When the current stops flowing in the electromagnet a spring pulls the armature back to where it started from. This motion closes the contact and the current flows again to the electromagnet. When the electromagnet is magnetized by the current the armature is pulled toward it again. This causes the clapper to hit the bell once more. The contact points are again pulled apart, repeating the whole process once more.

Exercise 23
Part 3

This alternate opening and closing of the circuit will continue as long as the door bell button is pushed.

QUESTIONS

These questions refer to the diagram of the simple door bell. Put a circle around the letter in front of the correct answer.

1. One side of the contact point is attached to the armature. What is the other side of the contact point attached to?

   A. The clapper
   B. The electromagnet
   C. A spring
   D. The base of the bell

2. What causes the armature to return to its starting position:

   A. The clapper
   B. The fixed contact point
   C. The electromagnet
   D. The spring

3. When the door bell button is first pushed, the contact points are

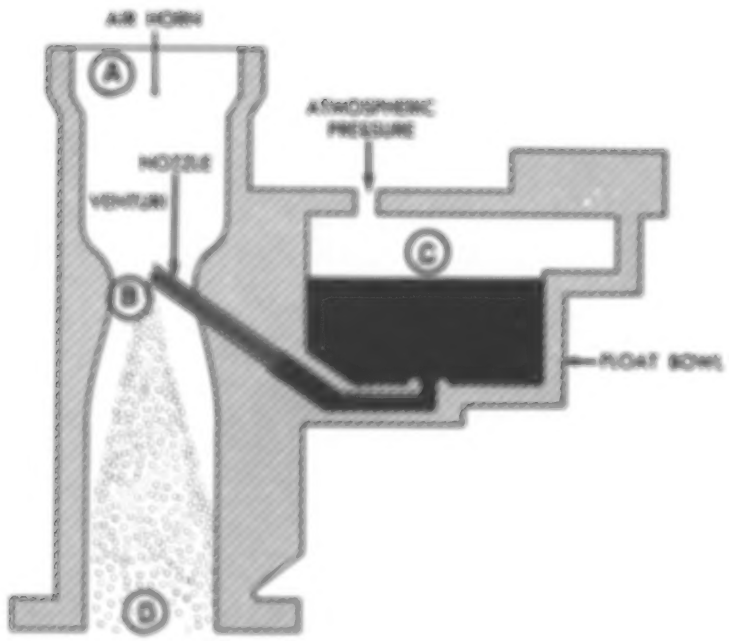
   A. closed.
   B. open.

4. Which of the following is not in the electric circuit?

   A. The door bell button
   B. The armature
   C. The electromagnet
   D. The clapper

Exercise 23
Part 4

A SIMPLIFIED CARBURETOR



A carburetor is one of the essential parts of a gasoline engine. The drawing shows a greatly simplified carburetor. Only the basic parts are shown.

The carburetor mixes the gasoline and air by means of atomization. Atomization means breaking a liquid down into very tiny particles.

One of the parts of a carburetor is a venturi. This is an hourglass-shaped restriction placed in the air horn. All the air going into the engine intake manifold and the engine cylinders passes through the air horn.

The purpose of the venturi is to create a partial vacuum at the outlet nozzle. The nozzle can be seen in the diagram sticking into the venturi. The partial vacuum allows the atmospheric pressure on the surface of the gasoline in the float bowl to force the gasoline out through the nozzle. The nozzle atomizes the gasoline into the passing air to form the fuel-air mixture.

Exercise 23
Part 4

QUESTIONS

These questions refer to the diagram of the simplified carburetor. Put a circle around the letter in front of the correct answer.

1. At what point is the pressure the least?

   A. Point A
   B. Point B
   C. Point C
   D. Point D

2. The venturi is between the air horn and the

   A. nozzle
   B. carburetor.
   C. manifold.
   D. float bowl.

3. Which of the following atomizes the gasoline?

   A. The nozzle
   B. The float bowl
   C. The air horn
   D. Atmospheric pressure

4. Which part of a carburetor is shaped like an hourglass?

   A. The float bowl
   B. The nozzle
   C. The air horn
   D. The venturi

This is an experimental booklet intended to help young people learn basic principles and concepts of mechanics and technology by means of a series of aptitude training exercises. The exercises are similar to aptitude tests except that an explanation is provided of the underlying principle governing a particular class of items, as well as the correct answer.

This booklet is part of the curriculum and materials for teaching basic vocational talents being prepared under Contract OE-5-85-023 with the United States Office of Education.

Comments and suggestions will be appreciated. Address all correspondence to:

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